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YOU'RE NEXT

New Equipment for Batavia, Ill., Plant

SYNOPSIS—The addition of a 7500-kw. turbine increases the total capacity to 16,000 kw. Feature of the new installation is the condenser and auxiliaries.

The Batavia plant, which is about 40 miles southwest of Chicago, furnishes power to the Aurora, Elgin & Chicago R.R. and other traction interests. Current is also supplied for lighting the cities of Elgin, Wheaton, West Chicago and Lombard, and several smaller towns.

Originally, the equipment included four Cooper-Corliss horizontal cross-compound engines connected directly to 1500-kw. three-phase generators. A vacuum of 25 in. was carried on barometric condensers and ten 500-hp. Edge Moor boilers supplied the steam. Late in 1910, a 2500-kw. mixed-pressure turbine was installed and so connected that it could take exhaust steam from either pair of reciprocating units or live steam from the boilers. The station economy was bettered 16 per cent. without adding to the number of boilers, although four more were eventually installed for reserve capacity.

The increasing demand for power made it necessary to again enlarge the plant. Last summer, a 7500-kw., seven-stage horizontal Curtis turbine, driving a 2300-volt, three-phase, 25-cycle generator at 1500 r.p.m., was put in operation. This necessitated the installation of four additional 500-hp. boilers, raising the total capacity to 9000 hp.

The generating unit, shown in Fig. 1, is of standard design, but the condensing equipment embodies some new features recently perfected by the Alberger Pump & Condenser Co. The condenser is of the new "Spiroflo," two-pass type, having 15,000 sq.ft. of 1-in. tube surface and, at 29 in. of vacuum, a capacity to condense 130,000 lb. of steam per hour with 17,600 gal. per min. of 70-deg. cooling water. The arrangement of the condenser is shown in Fig. 2.

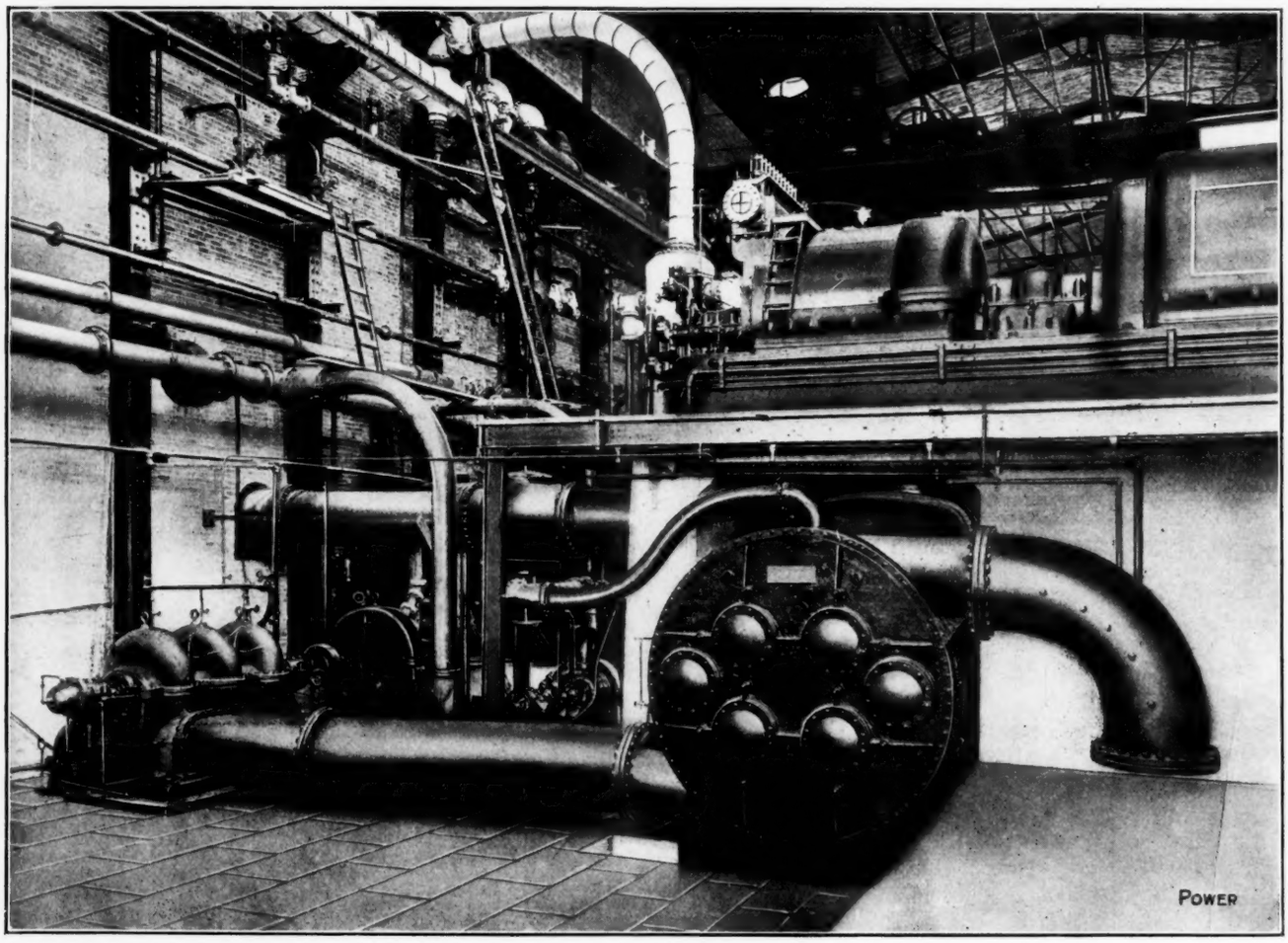


FIG. 1. VIEW OF TURBINE AND SPIROFLO SURFACE CONDENSER AT THE PLANT OF THE AURORA, ELGIN & CHICAGO R.R. CO.

Theoretically, a condenser of triangular cross-section is considered best, as the amount of surface decreases with the steam to be condensed and the air may be efficiently collected and removed at the apex. With this arrangement, practically all of the tube surface is active and, consequently, less surface need be installed. In the condenser under discussion the advantages of a triangular cross-section are secured by the use of a spiral

partition or baffle which so divides the surface that the area exposed to the steam is gradually reduced. The air from over the full length of the steam space is collected in the baffle and removed at the two ends. It is cooled on its way through and the water of condensation carried along with the air is removed through water-sealed drains provided on the under side of the baffle.

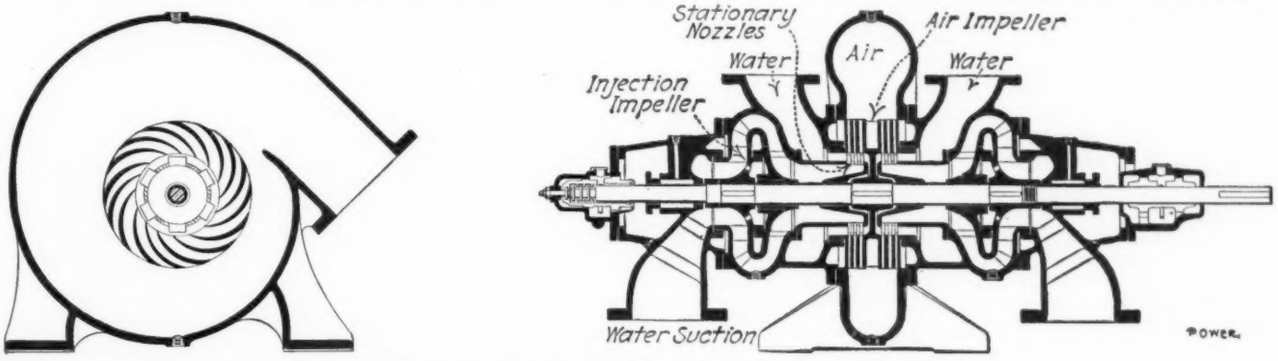
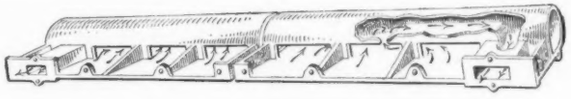


FIG. 3. DETAILS OF HYDROFLO DRY-AIR PUMP

From the spiral baffle in the condenser the air is removed by a new type of centrifugal dry-air pump, shown in vertical section in Fig. 3. As is apparent, the pump is provided with an injection impeller on either side of a double air impeller, so that there are two air- and two water-suction openings. The injection impeller lifts the water from the suction supply and gives it an initial pressure which changes into velocity as the water is discharged through stationary nozzles into the air impeller.



PERSPECTIVE VIEW OF SPIRAL BAFFLE AND AIR COOLER

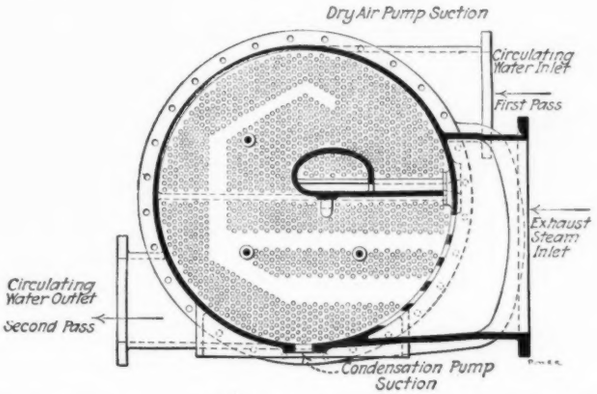


FIG. 2. PERSPECTIVE VIEW OF SPIRAL BAFFLE AND AIR COOLER AND END VIEW OF THE SPIROFLO SURFACE CONDENSER

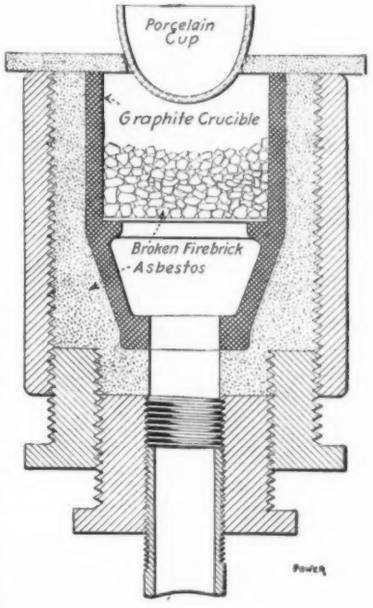
Air is admitted between the stationary nozzles and the impeller so that alternate plugs of water and air are introduced into the passages of the impeller and discharged by centrifugal force into the volute casing and thence to the atmosphere. An important feature of the pump is the water impeller. As this creates the initial velocity, the vacuum may be lost and the pump will not lose its suction, so that there is no occasion for priming.

Cooling water for the condenser is drawn from Fox River through a tunnel by a 28-in. tri-impeller turbo-volute pump. It is delivered to the condenser on the side opposite the steam inlet and a portion of it passes through the air-cooling tubes in contact with the baffle. Partially heated, the water then enters the tubes of the second pass on the inlet side of the condenser, so that the hottest water comes in contact with the steam at the entrance. Through a second tunnel the water flows back to the river some distance down stream and is discharged at a point just below a dam erected to insure a sufficient supply of water at all seasons.

Both the dry-vacuum and circulating pumps are driven by Alberger-Curtis single-stage turbines consisting of one wheel carrying three rows of moving blades and two rows of stationary blades secured to the casing. The former requires a turbine of 70 hp., and a 120-hp. turbine drives the circulating pump. Condensation is removed from the bottom of the condenser by a motor-driven, two-stage, 4-in. centrifugal pump.

Retort for Burning Coal Samples

Those who have city gas in their engine rooms and test the coal used in their plants will find the little retort herewith illustrated a good one for burning the samples. It is made from a coupling and reducers as a casing to hold a graphite crucible separated by asbestos. Graphite bars as grate bars are laid on lugs on the crucible, and broken firebrick, in pieces a little smaller than a hickory nut, are laid on the grate. A piece of sheet asbestos with a small hole in the center serves as a cover to prevent the rapid radiation of heat and to hold the porcelain cup containing the coal.



RETORT FOR BURNING COAL SAMPLES

The bottom reducer should be small enough to take a ⅜- or a ½-in. pipe through which a mix-

ture of air and gas is led to the bottom of the crucible. The retort works on the surface-combustion principle. When the firebrick reaches a light cherry-red heat no flame is visible, and soon the brick becomes white hot.

This retort was originally made and used by William Freer, power engineer for the American Locomotive Co., at Schenectady, N. Y. The retort is not patented, and individuals are free to make them for themselves.

Gas Passage in Return-Tubular Boilers*

By Osborn Monnett†

SYNOPSIS—The following discussion applies to the use of the bituminous coals found in the Middle West, more particularly Illinois coals, whose average composition is about as follows: moisture, 8 per cent.; ash, 12 per cent.; volatile matter, 32 per cent.; fixed carbon, 48 per cent.; heat value, 10,900 B.t.u. Lower-grade coals, lignites, etc., found further West, need special consideration and the data given herewith must be varied to suit local conditions, with such fuels. The grate area and arrangement of dampers and breeching are considered.

Grate Area for Return-Tubular Boilers

The ratio between heating surface and grate surface has an important bearing on the production of smoke, especially in hand-fired units. For hand-fired installations this ratio should not be as large as with mechanical stokers. In Table 1 is a set of dimensions for different sizes of horizontal return-tubular boilers giving the area of heating surface, horsepower and ratio of grate to heating surface. These dimensions are satisfactory for suitably designed hand-fired furnaces. Low ratios for the smaller boilers are employed because the small boiler does not usually get the expert attention required to operate smokelessly with high ratios. With the low ratios, providing liberal grate area, the fires do not have to be cleaned so often and the operating conditions are more nearly those which the ordinary fireman can handle without trouble. With the larger sized units usually installed in the more important plants, the supervision is better, the class of labor is higher and ratios of from 40 to 48 to 1 can safely be employed.

TABLE 1. HORIZONTAL RETURN-TUBULAR BOILER DATA

Size Diam. In.	Size Length Ft.	Dimensions of Grate Width	Dimensions of Grate Length	Grate Area Sq.Ft.	Heating Surface Sq.Ft.	Rated Horsepower	Ratio Heating to Grate Surface
54	14	4	4½	18	628	63	35 to 1
54	16	4½	4½	20¼	718	72	25 to 1
60	16	5	5	25	896	90	36 to 1
60	18	5½	5	27½	1008	101	38 to 1
60	16	5½	5½	30¼	1043	104	37 to 1
66	18	5½	5½	30¼	1173	117	39 to 1
72	16	5½	6	33	1327	133	40 to 1
72	18	6	6	36	1493	149	41 to 1
78	18	6	6½	39	1843	184	41½ to 1
78	20	6½	6½	42½	2047	205	48 to 1
84	18	6	7	42	1937	194	46 to 1
84	20	6½	7	45½	2153	215	47 to 1

Size of Gas Passage at Rear

In setting return-tubular boilers, many builders restrict the gas passage at the back head, which is detrimental to good operation. Table 2 shows dimensions that can be recommended for this space.

Damper Design

The tube area, fixed by the manufacturer, is generally sufficient to allow the gases to pass freely to the stack while working at ordinary commercial capacities, consequently, this need not be discussed.

Restriction at the damper reduces the amount of coal which can be burned per unit of time and, therefore, is a limitation on capacity. Further, it tends to shorten the life of the brickwork of the furnace and setting because if the gases cannot pass off freely the heat will be "bottled" and the brickwork will melt.

A common form of uptake is shown in Fig. 1. This gives a long and narrow opening which is not as good, even though it is of the required area, as one more nearly square. The damper of a return-tubular boiler should provide a free opening 25 per cent. in excess of the total tube area. Fig. 2 shows the design of an ideal damper and the dimensions for dampers for different sizes of boiler are given in Table 3.

TABLE 2. DISTANCE FROM BACK HEAD OF BOILER TO COMBUSTION CHAMBER WALL

Size of Boiler												
Diameter, in..	54	54	60	60	66	66	72	72	78	78	84	84
Length, ft....	14	16	16	18	16	18	16	18	18	20	18	20
Back head to wall, in....	26	26	28	28	30	30	32	32	34	34	36	36

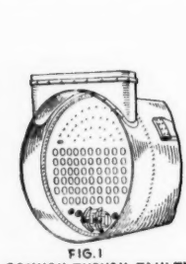


FIG. 1
COMMON THOUGH FAULTY FORM OF UPTAKE

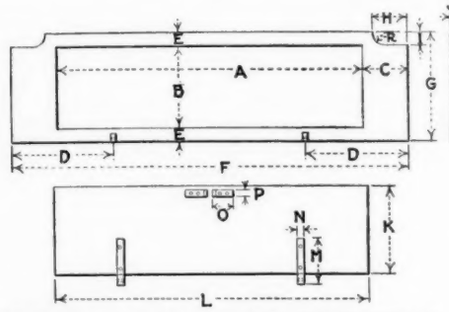


FIG. 2—DESIGN FOR IDEAL HORIZONTAL RETURN TUBULAR BOILER DAMPER

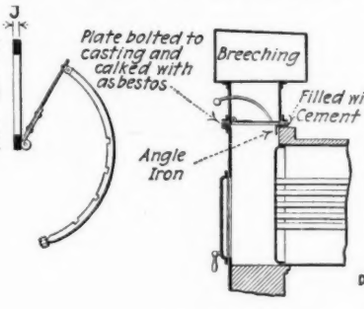


FIG. 3
IDEAL DAMPER AND UPTAKE ARRANGEMENT

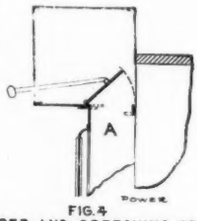


FIG. 4
DAMPER AND BREECHING CONNECTION FOR LIMITED HEAD ROOM

Showing Faults and Proper Arrangements of Uptake and Damper for Return-Tubular Boilers

*Copyright, 1914, by Osborn Monnett.

†Smoke inspector, city of Chicago.

This type may be applied to continental or marine types of boiler, also to the Hawkes, Kroeschell combination and Lyons boilers. The object of this design is to avoid the long and narrow opening as far as possible and obtain a free passageway for the gases to the stack. necessary, it should be a long sweep bend. Sharp right-angle turns in the breeching should be avoided and likewise sudden changes in cross-section. The connection to the stack should also be in an easy sweep to avoid a drop in draft at this point. Fig. 5 is a good

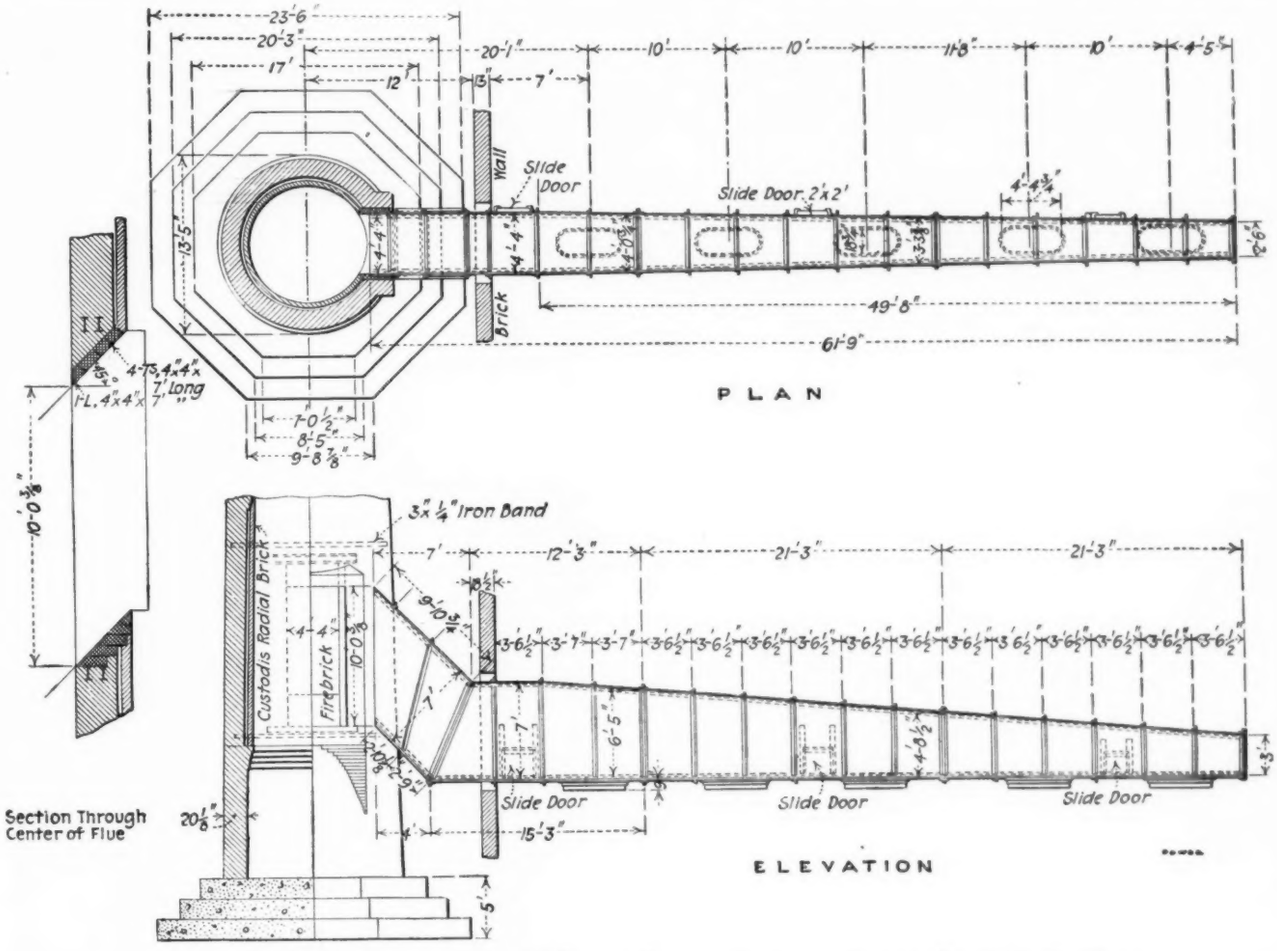


FIG. 5. MODEL BREECHING AND STACK CONNECTION FOR RETURN-TUBULAR BOILERS

Fig. 3 shows another design of damper which eliminates the damper plate and gives a maximum opening into the breeching. Fig. 4 shows a good damper and

TABLE 3. DIMENSIONS IN INCHES FOR DAMPER SHOWN IN FIG. 2

Diameter of Boiler, In.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
36	24	10	8	12	3	40	16	5	2	1	13	25	6¾	1	3	1	2
42	36	10	7½	13	3	46	16	5	2	1	13	37	6¾	1	3	1	2
48	38	10	7	14	3	52	16	5	2	1	11	39	6¾	1	3	1	2
54	44	12	6½	14½	2	57	16	5	2	1	13	45	6¾	1	3	1	2
60	49	15	6½	11½	1½	62	18	5	2½	1	16	50	6¾	1	3	1	2½
66	54	15	6½	14¼	1½	67	18	5	2½	1	16	55	6¾	1	3	1	2½
72	60	18	6½	16	1½	73	21	5	2½	1	19	61	6¾	1	3	1	2½

breeching connection where head room is limited. The dotted lines indicate how this damper was originally installed. Draft readings taken before the change was made showed 0.52 in. over the damper and 0.26 in. below at point *A*, indicating a direct loss of 0.26 in. After the change the draft at point *A* was increased to 0.49 in. and a free direct passage to the breeching was obtained.

BREECHINGS

Breechings should be laid out with the run to the stack as short and direct as possible, and wherever a turn is model to follow with horizontal tubular boilers. It shows in detail a breeching serving five 150-hp. boilers and the stack connection designed for maximum draft efficiency.

Large Elevator Installation—The 23 passenger elevators in the Continental & Commercial Bank Building, Chicago, are known as the gearless traction electric type. This type possesses some features which differ considerably from those of the geared type; for example, the hoisting cables are not wound on a drum, but drive over a sheave which is bolted directly to the armature spider of the motor by means of a flange, integral with the spider. The necessary tension in the wire cables to secure tractive force between the driving sheave and the hoisting cable is secured by passing the cables partially around the traction driving sheave and then around an idler leading sheave, forming a complete loop around both sheaves. The car and the counterweight are suspended from opposite ends of the cable, thus avoiding the use of intermediate gearing. The motors used in this elevator system are of the slow-speed shunt-wound type, with a capacity of 35 hp. The normal capacity of each elevator is 2500 lb., lifted at a speed of 500 ft. per minute. To insure safety the motor is equipped with a governor which regulates the motor speed regardless of the load. At the bottom of each shaft there is an oil-cushion buffer which brings the car to a stop, being regulated by the escape of oil from one chamber of the buffer to another.—"Engineering and Contracting."

New Turbine Power Plant of the Louisville Railway Company--II

By W. O. Rogers

SYNOPSIS—The boiler room is arranged for future extension, and has eight 500-hp. water-tube boilers. There will ultimately be 16 additional units and a second chimney 225 ft. high. Fuel is elevated to the coal bunker above the boilers in 2-ton hand, push cars, by means of two 6000 lb. capacity platform elevators. Ashes are handled in the same manner and are discharged into an ash hopper from which they are loaded into railway cars.

The initial boiler installation in the High Street Station of the Louisville Railway Co. consists of eight 500-hp. water-tube units, Fig. 9. Provision has been made for eight additional boilers of the same size. The steam pressure is 180 lb. superheated 125 deg. at the normal rating of the boilers, which have parallel drums. The tubes are 14 in. high and 18 in. wide. Each boiler furnace is equipped with an engine- or motor-driven chain-grate stoker with a grate 9 ft. 6 in. wide by 12 ft. 3 in. long, a total of 153 sq.ft., or 1 sq.ft. of grate surface for each 3.26 boiler horsepower. The boiler settings are much higher than usually employed, the front end of the tubes being 6 ft. above the grates. This gives a large combustion chamber in which to burn Kentucky pea and slack coal, which will be used.

These boilers are served by a red, radial brick chimney, 255 ft. high and 13 ft. inside diameter at the top, and built on a concrete foundation which goes down to bed rock. The stack has sufficient area to provide a square foot for each 36.25 boiler horsepower and was designed to serve the eight boilers installed in two batteries on each side of it. Foundations for a second stack and for a second row of eight boilers have been provided on the opposite side of the room. The second chimney will be 255 ft. high and 18 ft. in diameter, and will ultimately serve 16 additional boilers.

Fig. 9. Eight 500-Hp. Water-Tube Boilers

The present stack, with six boilers in service, gives a draft of 1.2 in. of water. Over the front of the grates and at the main breeching with the damper open, the draft is 0.45 in. of water. A preliminary test of the

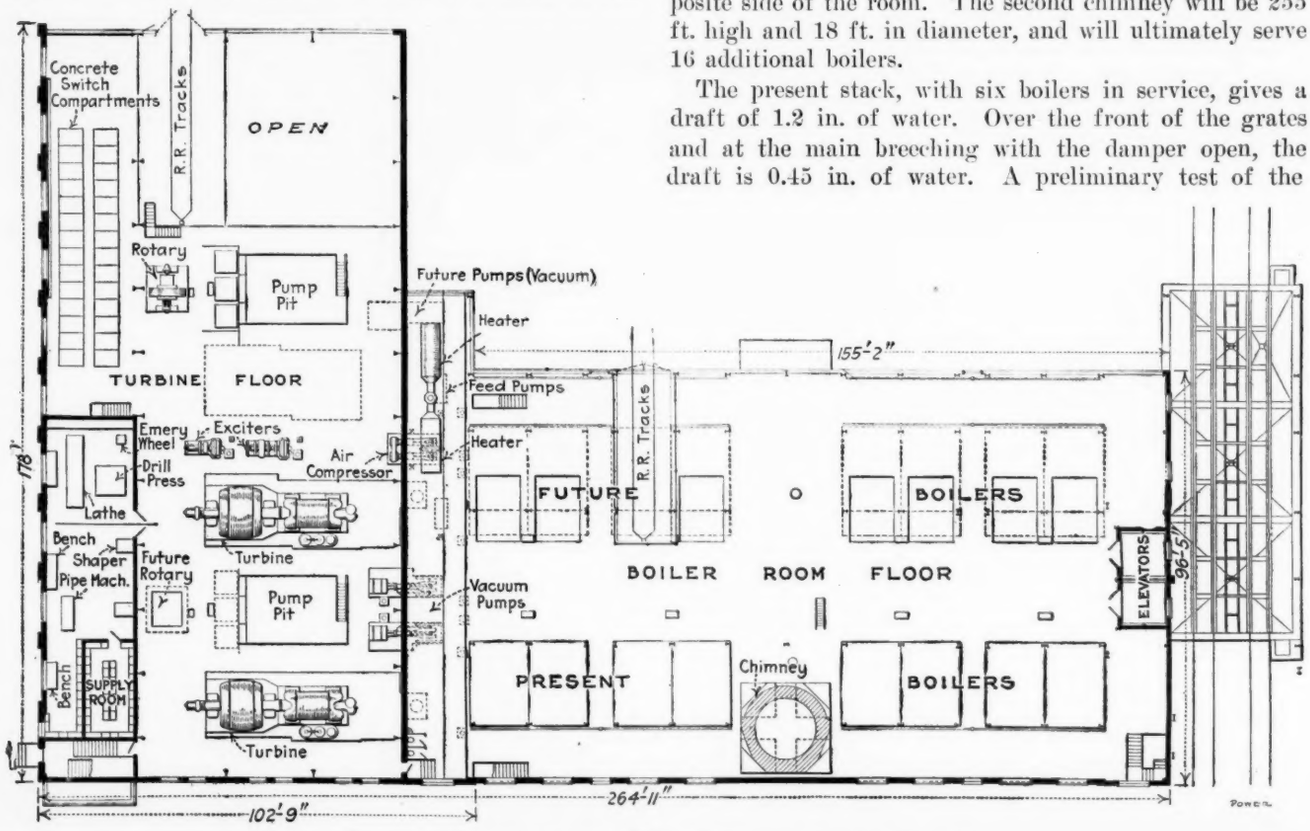


Fig. 10. Plan of the New Turbine Power Plant

boiler and station efficiency during the second month of operation, before all of the steam pipes were covered and while some steam was being used for drying-out purposes, gave a coal consumption of 2.975 lb. per kw.-hr. with 12.5 per cent. ash. The coal tested was approximately 12,000 B.t.u. dry. Figs. 10 and 11 are plan and elevation views of the plant.

Coal and Ash Handling

All coal is received from the steam railroad on two side tracks, which run over three concrete track hoppers at the outside end of the boiler house. From the hoppers the coal is loaded by gravity into two-ton, hand-push steel cars, Fig. 12, which are wheeled onto either of two electrically operated platform elevators, each with a capacity of 6000 lb. The loaded car is hoisted to a level with the industrial track above the coal bin which runs from the elevator shaft over the coal bunkers, and the cars may be pushed to any desired point for dumping. The elevators are designed to run at 100 ft. per min. One is driven by a 550-volt, direct-current motor, the other by a 440-volt, three-phase alternating-current motor; each is of 30 hp. capacity.

Each battery of two boilers is equipped with a coal bin holding 225 tons, a supply sufficient for 4½ days

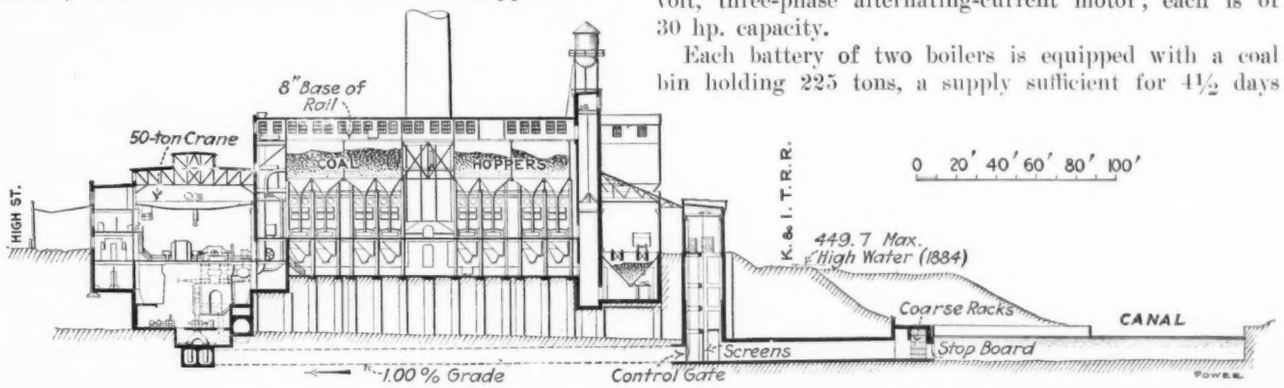


Fig. 11. Elevation of the High Street Power Station

Fig. 12. Room below Track Hoppers from Which Coal Is Loaded into Push Cars

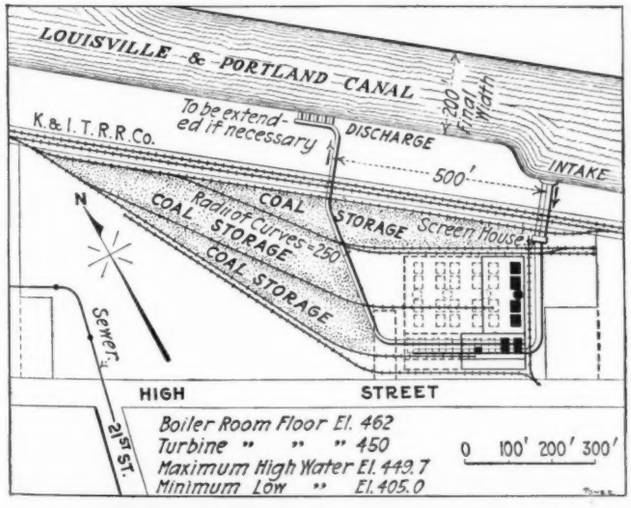


Fig. 13. Showing Coal Storage outside the Power Plant

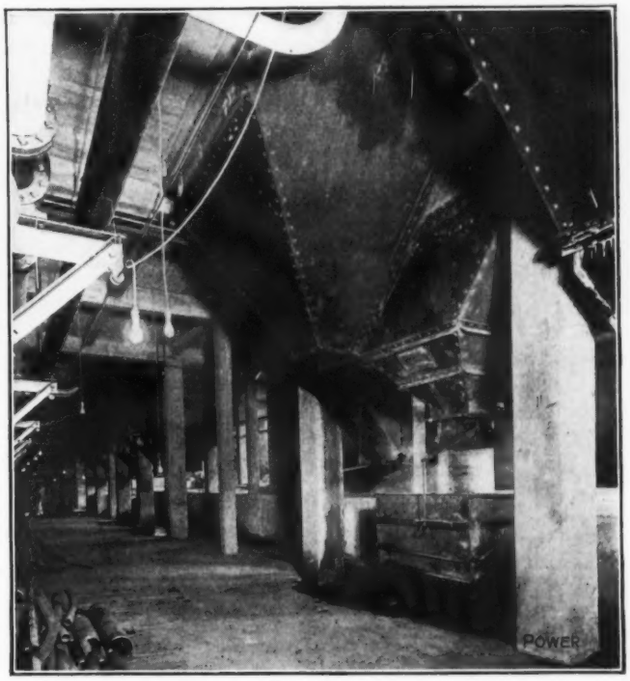


Fig. 14. Coal and Ash Hoppers and Ash Car in Boiler-Room Basement

under ordinary operation. The bin of this size is a precautionary measure against a shortage of coal during extreme high-water periods, when the railroad tracks are submerged. The coal-storage capacity of the yard, Fig. 13, is limited only by the height to which the coal may be piled. The side tracks, which are about 4000 ft. long, are capable of storing 90 loaded cars, or about two days' fuel supply.

The ashes drop from the furnace grates into one of two steel ash hoppers, lined with firebrick, and are dumped into push cars, Fig. 14, on an industrial track which

passes underneath. The other hopper catches siftings from the grates, which are discharged into a car and returned to the coal bunkers. The loaded ash cars are elevated to a steel firebrick-lined ash hopper installed over the coal-unloading hoppers, outside the boiler house. By this arrangement, after the coal has been unloaded, the same car may be filled with ash from the ash hopper overhead. This method of handling coal and ash, it is estimated, will show an overall saving of approximately 20 per cent. as compared with the continuous-conveyor systems.

Piping System

There is one main steam header installed over the front of the boilers and at right angles to the turbine room. The header varies in size from 12 to 16 in. and is connected to a cross-header at the end of the boiler room, running parallel to the turbine room. From this cross-header steam is taken to the turbines through two 12-in. long-radius bends. Two 10-in. long-radius bends take steam to an auxiliary header in the basement of the turbine room, from which all auxiliaries are fed.

When additional boilers are installed, a ring system of steam piping is contemplated which will encircle the boiler room and permit cutting out of service any battery of boilers. All the headers and valves are of cast steel and the boilers are safeguarded with automatic cut-off valves.

All steam piping 4 in. in size and over is designed to carry 200 lb. pressure and 125 deg. superheat, and is covered with a layer of 1-in. fire felt, followed by a molded layer of 85 per cent. magnesia, 2 in. thick and covered with 8-oz. duck. All the piping, including 1-in. and smaller, is insulated with 1-in. thick fire felt and covered with duck. The cold-water piping, where condensation might cause trouble, is covered with 1-in. anti-sweat covering, and exhaust steam and hot-water pipes with 1-in. asbestos air-cell covering.

The building was erected according to architectural plans made by D. X. Murphy & Bro., of Louisville. They were drawn from designs laid down by F. H. Miller, superintendent of motive power of the company, to whom the writer is indebted for photographs and drawings, the former being unobtainable when the plant was inspected.

Progress of the Smoke-Abatement Movement in Europe

By John C. Kershaw

SYNOPSIS—Outlining what has recently been done in Europe in attacking the smoke evil. Hamburg has a smoke-prevention society made up of manufacturers, the membership being 434. This society's engineering staff makes tests, inspections and alterations in the members' plants for the purpose of stopping smoke production and of increasing the efficiency. Finland is active in smoke abatement. Twenty-four English and Scotch cities are making soot observations with standardized apparatus and methods. Hamburg has joined this movement. Technical educational authorities in many English and Scotch cities have included classes for engineers and firemen in their curricula. Glasgow a leader in this work.

The problems of smoke abatement are intimately associated with those of boiler efficiency and of fuel economy. This connection between smoke and inefficiency is today quite clearly recognized. Although a strong case for smoke abatement can be made out on hygienic grounds, it will always be the economic argument that is the most convincing to the man who is actually producing smoke. Prove to him that a cleaner chimney top means a smaller coal bill, and he will become an ardent and willing helper in a campaign against black smoke; whereas in the absence of this proof he will remain an indifferent witness, or energetic opposer.

This connection between smoke abatement and improved fuel economy has been clearly and usefully demonstrated in Germany and Finland, by the work of the two smoke-abatement societies established in Hamburg and in Helsingfors, the latter society being an offshoot of the former. The Hamburg parent society—the Verein für Feuerungsbetrieb und Rauchbekämpfung—was founded in 1902. According to its last report, it has 473 members and 1593 steam boilers or other heating appliances on its register; and it is of interest to note that nearly all the members are manufacturers or factory owners who have joined for the benefits that can be obtained in the more scientific control of their boilers. The society is a voluntary association of large consumers of fuel bound together simply by the common desire to obtain the highest possible efficiency and the minimum of smoke. Each annual report contains numberless examples of the improvement in efficiency that results when the engineering staff has taken charge of the plant.

When the skilled engineers and firemen of the "Verein" took control of the plant I have in mind, they changed the conditions of working as regards draft, admission of secondary air and the thickness of the fuel bed. Burning less coal, they evaporated more water and raised the efficiency of the two boilers from 58.6 to 70 per cent.; this is equal to a reduction in the coal bill of 20 per cent. The reports are full of equally striking examples of the economies gained by skilled supervision of boilers, combined with the work of properly trained and paid firemen. It is strange that this method of attaining such striking and valuable results by the voluntary association of fuel users has not been more widely adopted. In the hope that some American cities may follow Hamburg and Helsingfors, a few notes on the organization of the Hamburg society are given:

The work is controlled by a committee of from six to nine members, elected annually from the rank and file, at the general meeting. The technical and scientific work is undertaken by the staff of experts retained by the society. At the date of the last report this staff consisted of a chief engineer, three assistant engineers, five instructors for firemen, and two clerks, while for special

steam-raising and other trials, additional assistance had been employed. The chief engineer attends the committee meetings and takes part in the discussions relating to the work. The funds are drawn from three sources: 1. From the annual subscriptions of its members. 2. From payment for special work and reports for its members. 3. From payments for outside work.

The society is thus entirely self-supporting, and its success is dependent upon the value of the return it makes to its members for their contributions and fees. It is, therefore, gratifying to note that the membership shows steady growth.

The objects are the attainment of the highest possible efficiency from the heating and boiler plants of the members, with the least possible emission of smoke. To this end, regular examination of these plants and of the methods of working them are undertaken by the engineering staff, and suggestions are made for improvements when such are required. The education and control of the firemen in their duties are also undertaken by the firemen instructors on the staff. Comparative tests of fuel, and tests of smoke prevention and other appliances, are also carried out by the expert staff, and the results are circulated among the members. Members can demand that boilers or heating plants shall be regularly inspected, and that their working shall be tested and reported on at least three times a year. They have also the right to consult the chief engineer of the society regarding improvements and alterations in design and operation.

Further details of organization and rules may be found in a paper contributed by the writer to the London Smoke Abatement Conference of 1905.

Turning to the progress of the smoke abatement in the United Kingdom, the most notable events of the past year have been:

1. The introduction into the House of Commons of a bill to amend and extend the existing laws against smoke emission. 2. The inauguration of soot-gage observations by 24 of the larger cities and towns of the country, on the lines of those carried out by the *Lancet* in 1910-1911. 3. The continuation of the educational classes for firemen and engineers in London, Glasgow, Liverpool, Manchester and many other large cities.

The Smoke Abatement Bill, which was introduced into the House of Commons on Apr. 30, 1913, has for its object the extension of the powers of the local authorities and of the local government board in relation to the nuisance caused by the improper emission of smoke.

Section 1 makes it incumbent upon the owner, occupant, or user of a furnace to have it so constructed that it will consume its own smoke, and the emission of smoke or grit from such furnace or its chimney is constituted a nuisance. At the same time the local government board is given powers to make special exemptions where it is impracticable to avoid making smoke in carrying on a business, but such "power to exempt" is limited to ten years from the passing of the act, and the exemption must be renewed every two years.

Section 3 authorizes the local government board to appoint local smoke-abatement authorities in those areas in which the local sanitary authorities are failing to carry out their duties as to smoke abatement. In London, the London County Council is made the local smoke-abatement authority.

This bill was reintroduced into the House of Lords in March, 1913, by Lord Newton, and was only withdrawn on the promise of the government to appoint a commission of experts to report on the whole subject of smoke, and to indicate the lines upon which further legislation is desirable.

Under Section 4, local inspectors may be appointed by the local authority, subject to certain requirements as to experience and to the control of the local government board.

By Section 5 the local government board is given the right to inspect the records of offenses in order to see if the local authority is properly carrying out its duties and subject to such obligation being satisfied, the local government board may pay not more than half the salary of local smoke inspectors by way of grant in aid. The same section requires the central authorities themselves to appoint government smoke inspectors, and gives such inspectors power to prosecute in cases where the local authority has failed to do so.

Soot and Dust Observations

At the International Exhibition of Smoke Abatement Appliances and the conference on the black-smoke problem held in London in March, 1912, a committee was appointed to draw up specifications for a standard apparatus and a method for measuring the extent and character of the air pollution in cities and towns. Numerous meetings of this committee were held in London in 1912-1913 under the presidency of Dr. Norman Shaw, chief of the Government Meteorological Office, and eventually a type of apparatus and method was selected, based on that used for the *Lancet* observations in London in 1910-1911, with certain modifications suggested by experience.

The health authorities of 20 English and Scotch towns and of several of the London boroughs have agreed to join in this work of recording the character and amount of atmospheric impurity. The following towns have joined: Aberdeen, Ayr, Birmingham, Coatbridge, Exeter, Glasgow, Greenock, Hull, Liverpool, Leicester, Leith, London, Malvern, Manchester, Newcastle-on-Tyne, Oldham, Paisley, Plymouth, Sheffield, Stirling, Wishaw and York. Hamburg is also to commence observations with the standard method and apparatus, thus giving the movement an international character.

Educational Work in English Cities

The classes for firemen and engineers started in many cities are being carried on with increasing success, and they appear to meet a real need. It is hoped in time to create a standard of merit and efficiency and to issue certificates to successful members.

It is gratifying to note that the technical education authorities of many large towns and cities are now including classes for firemen and boiler engineers in their curricula. So far, Glasgow has been the most successful in conducting these classes, which are carried on during the winter months at several different centers in the workingclass district, and are under the charge of the smoke inspectors of the municipality. Between 100 and 200 firemen have been enrolled each winter in these classes at Glasgow since they were initiated four years ago, and it is now proposed to start a class for the more advanced students who have satisfactorily passed through the elementary course of instruction. Glasgow also ar-

ranges a course of public lectures each winter for the more educated part of the commuity.

Reference must be made to the increase in recent years, in the number of gas- and electrical-heating appliances employed for domestic purposes, especially in London and the larger towns, where coal is comparatively dear and gas is cheap. The records of the gas and electric-supply companies prove how rapidly the domestic consumer is availing himself of these substitutes for coal, and there is reason to hope that before the first quarter of the twentieth century has passed away, gas and electricity will have largely replaced raw coal as a source of heat in the English household.

Europe has had a year of progress.

The Kapp Phase Advancer

By Arthur H. Allen

SYNOPSIS—By means of three small direct-current motors connected in circuit with the rotor of an induction motor, an e.m.f. is produced in opposition to that produced by the slip of the rotor and the power factor is raised to unity or above.

Considerable attention has been devoted lately in England and on the Continent to the problem of phase advancing, with a view to improving the power factor of alternating-current circuits, especially those having induction motors. A machine invented for this purpose by Prof. Gisbert Kapp, a well known pioneer in electrical engineering, has recently been installed in connection with a 330-hp. motor at a cement works near Middlesbrough, England. The motor is supplied with power at 2750 volts, 40 cycles, and runs at 400 r.p.m., the power factor at half load being 0.76, and at full load 0.87.

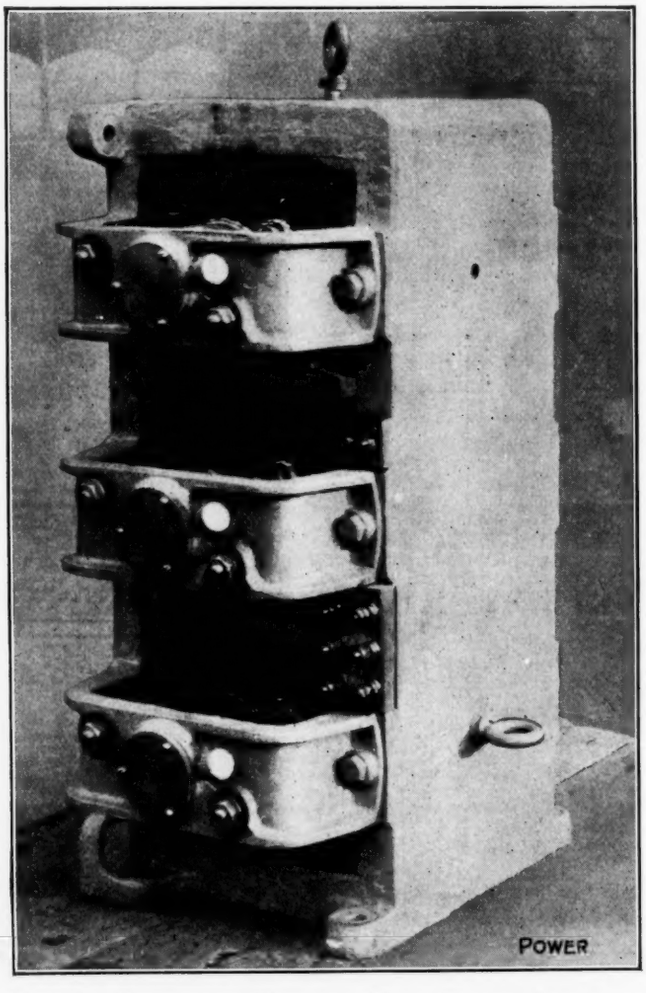


Fig. 1. Assembled View of Kapp Phase Advancer

The phase advancer, or "vibrator," Fig. 1, is a small machine, with three ordinary direct-current armatures running in two-pole fields, which are separately excited with direct current. The armatures are only 4 in. in diameter, and at full load, when the motor has a slip of 2.45 per cent., or about one cycle per second, the armatures reverse their direction of rotation every half second, making about 3½ revolutions in each direction. Connections of the machines are shown in Fig. 2, from which it will be seen that the three armatures are connected in mesh to the slip rings of the rotor winding, and are traversed by the currents flowing in that winding.

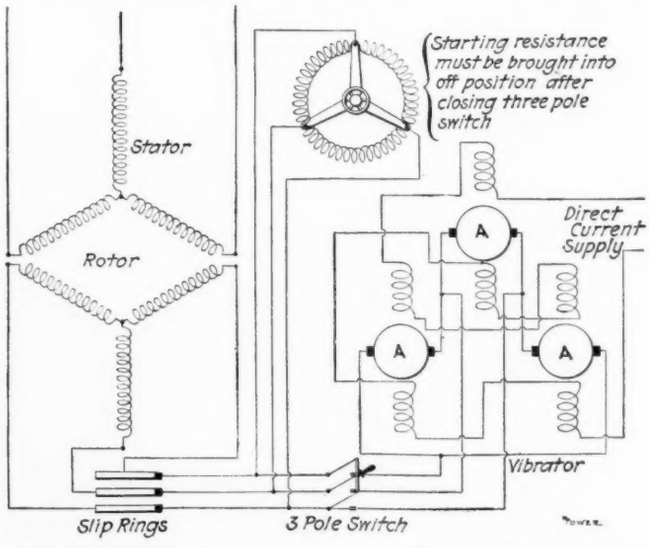


Fig. 2. Connections between Motor and Phase Advancer

Reversals of this current cause the reversals of rotation mentioned, but, owing to the inertia of the armatures, the latter lag in phase behind the rotor currents, so that when the current in an armature is approaching its maximum, the armature is coming to rest. Thus the commutator is almost stationary when the current is a maximum, and is moving most rapidly when the current is zero, conditions which are favorable to sparkless operation. The rotation of the armature induces an e.m.f. which is opposed to the e.m.f. of self-induction in the rotor winding, and is greater than the latter by an amount sufficient to supply, through the resistance of the rotor, the necessary current to produce the magnetic field of the motor. With normal excitation of the vibrator, no magnetizing current flows in the stator windings of the motor,

and consequently the latter operates with a power factor of unity. If the excitation of the vibrator be increased above this value, the extra voltage induced in the armature will produce in the rotor windings a magnetizing current greater than normal, so that a leading current will be induced in the stator windings, thus helping to improve the power factor of other motors on the same circuit.

The effect of the vibrator is shown by the curve in Fig. 3; at half load the power factor was brought up to 0.99 leading, and at full load to 0.96 leading. The power used for excitation was only 50 watts. Obviously, the power factor could have been made unity if desired, at either half or full load, by reducing the excitation.

The vibrator works equally well when the machine with which it is connected is running either as a motor or as a generator, without any change of connections, a property which enables it to be used with motors driving winding engines or locomotives, giving complete compensation under all conditions. If a fault should occur, the vibrator could be left in circuit with the motor, although out of action, as it would not affect the working of the motor, behaving, in fact, as a short-circuit on the slip rings. It should not, of course, be connected to the slip rings until the motor is running at full speed, and it is easy to provide interlocking gears to prevent the motor being started in this condition. The use of the vibrator also improves the operating conditions by considerably increasing the overload capacity and pull-out torque of the motor. The machine illustrated was built by Sandycroft, Limited, at its works near Chester, England, and is the first of its kind to be put into commercial use.

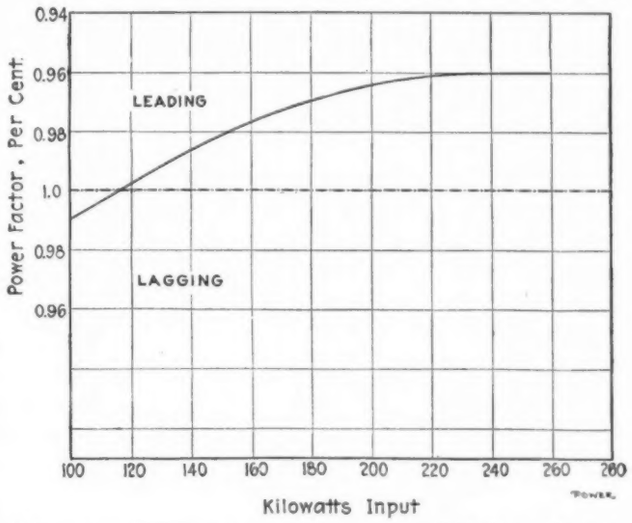


FIG. 3. POWER FACTOR CURVE OF 330-HP. MOTOR WITH KAPP PHASE ADVANCER

Emergency Repairs in the Early Days

BY R. A. CULTRA

How we do like to relate our experiences in the plants of long ago, especially where no spare parts, packing or hardly anything else was at hand in case of need. The usual tools were an old dilapidated oil can and a broken or badly battered monkey-wrench. Of course, the engineer was expected to bring a hammer and a cold chisel with him, and other tools if he had them.

It is true, the owners were not fussy about keeping such plants up to the best condition, and much less than fussy when the engineer worked nights, Sundays and holidays without extra pay, on repairs which could have been done in a few hours with proper material and tools.

In one place I put in a piece of pipe 3 in. in diameter and 5 ft. long, and the largest wrench in the plant was an 18-in. Stilson. A rope was wound around the pipe, some rosin put under it, and the ends tied together, forming a loop. Then the end of a piece of 2x4 in. timber was put through the loop and across the pipe. By pulling around the pipe, the rope would grip and turn the pipe. By this means, the joint was so tightly made up that a 3-ft. chain tongs and the combined efforts of two men were required to start the joint six months later.

Mr. Bedore, referring to page 491, Apr. 7, 1914, is not the only one who has made a pump piston out of wood; I have. In my case, it was a boiler-feed pump and there was no spare pump or injector in the plant. The pump had but little head clearance and a bolt from the suction valve, going down into the water cylinder toward the steam end, had broken the piston, which was made of two follower plates with an expansion ring between. A piece of hard wood was turned up $\frac{1}{16}$ in. smaller than the bore of the cylinder and put on the rod with a washer each side. The wood expanded enough to fill the cylinder, but did not bind. It ran nearly a month before a new piston was put on. Wood was selected which did not expand much, and the piston was made enough smaller than the bore of the cylinder to allow for expansion.

On one occasion, Jerry Perkins, the engineer over in the sawmill, having no sheet rubber, came over to get a piece of pasteboard box to pack the steam-chest cover of his engine. His pump valves had worn down as well; one had broken and the pump was out of service. Having no new valves, one was turned up out of lignumvitæ—some hard wood!—and Jerry put it in.

As a reward (?), the boss said he did not see why Jerry needed to buy pump valves when he could make them out of wood. Jerry got no more new valves. It was some plant! What with the flanges packed with pasteboard, the valve stems with hemp twine, the piston rod with rope, and the manhole gasket put in with hemp rope and white lead.

Jerry kept things quite tight at that, but he certainly had to work to do it!

First Use of the Panama Electric Towing Locomotives was made on Apr. 1, at Gatun Works. Locomotives 641, 642, 643 and 644 towed the launch "Balboa," clapet "No. 1," and a scow through the west flight from Gatun Lake to the Atlantic entrance channel. Clapet and scow were lashed together alongside, but the scow leading by half a length. The low freeboards gave as unfavorable inclination to the towing lines as probably ever will be secured in operation. Passage was completed in 1 hr. 17 min. which is only two minutes more than schedule fixed for operation. Extra lines were carried by laborers, but were not needed.

Will Quizz, Jr.

SYNOPSIS—Will waxes indignant at the electrical dictionary on the subject of the direction of rotation when a generator is converted into a motor. Chief Teller explains the subject.

"Good morning, chief! Last night that book of yours that asks itself questions and then answers them, tried to tell me that if a generator was connected up as a motor, and took current from the busbar, it would run in the opposite direction to that which it did to produce current as a generator."

"Well, what else did it say, Will?"

"Say!—It didn't say any more, because I simply shut it up and wouldn't let it stuff me. It may talk to itself that way, but not to me, because anyone knows better than that. Don't you remember over in the old plant that when the belt broke, No. 2 machine would keep on running in the same direction until the switch was pulled out?"

"Let's see, Will, those old machines were straight shunt, weren't they?"

"Yes, but what has that got to do with it?"

"Suppose we ask the book. But first do you remember that little arc machine we used temporarily as a motor when we were changing over; which way did that run?"

"Come to think of it, we had to reverse the leads to the brushes to get that one to run the way we expected it to."

"Yes, here it is in the book. Just as you said, the shunt machine rotated in the same direction, because the fields are in parallel with the armature and the arc or series machine rotated in the opposite direction, because the fields were in series."

"Well, it goes on to say that, of course, a compound-wound machine will rotate in one direction or the other according as its shunt or series winding preponderates, or they may just balance when there will be no motion at all. That makes it clear why machines will act differently, and why engineers have experiences which do not seem to tally."

"This book, Will, does not go into lengthy details in answering, but is good to refer to as the old Scotchman said of a dictionary, 'The stories are verra good, but verra short.'"

Transmission of Power by Manila Rope

By Reginald Trautschold

SYNOPSIS—Charts and formulas for figuring the power transmitted by rope drive, the sizes of sheaves, etc. Also the characteristics and advantages of rope drive are discussed.

Records show that rope manufactured from the fiber of palms was used in Egypt long before the days of Christianity. Such ropes were found in the tombs of Beni-Hassan (3000 B.C.) and on the walls of these same tombs are illustrations depicting the preparation of hemp. Carvings found in tombs in Thebes represent the process of making rope from thongs of leather, about 1600 B.C., and Assyrian sculptures of about 50 years later show gigantic hauling operations performed with rope. These records are of particular interest as indicative of the steps through which rope manufacture passed in the early ages.

Of the flexible ropes suitable for power transmission, a manila rope is just as strong as a solid steel bar, weight for weight, though only about 11½ per cent. as strong per equal cross-section. Leather, on the other hand, is only about 5 per cent. as strong as a steel bar of equal cross-section and less than 40 per cent. as strong per equal weight of material.

The relative efficiency of manila rope and leather belting for the transmission of power is not directly proportional to their respective strengths, however, as the internal construction of a hemp rope and a strip of leather differ greatly and are affected very differently by wear. Manila fibers, from which the rope is manufactured are usually from 8 to 10 ft. in length, are composed of elongated cells that possess great strength longitudinally but are comparatively weak transversely. Leather, on the other hand, is about equally strong in any direction so that the wear on such a belt is mostly external. In a manila rope the wear is largely internal, the elongated fiber cells being crushed together when passing around a sheave and breaking up into short pieces. A worn-out manila rope, as far as its strength is concerned, may have the outward appearance of an excellent rope while internally its construction is but a mass of short, broken particles. The allowable working stress of a good leather belt is customarily taken as 320 lb. per sq.in., or about $\frac{1}{10}$ its tensile strength. In the course of a year or so a manila rope will lose about 50 per cent. of its original strength, after which the weakening becomes more gradual. Under such conditions it is safe to figure on an allowable working stress of about 288 lb. per sq.in. or $\frac{1}{3\frac{1}{2}}$ its tensile strength.

The cross-section of a manila rope closely approaches a circle, and an allowable working stress of 288 lb. per sq.in. is equivalent to a maximum allowable tension of $225\ d^2$ (pounds), where d is the diameter of rope in inches.

The influences exerted against the productive force in a rope drive are those of centrifugal force, the tension required in the slack side to keep the rope from slipping and the air resistance, the latter negligible at low speeds but appreciable at very high speeds. The difference between the productive force and the sum of the unpro-

ductive forces, corrected for mechanical inefficiency of the sheaves, etc., will then give the useful power that can be transmitted by a rope drive.

Fig. 1 represents the distribution and consumption of power by various sizes of manila rope traveling at different speeds. The upper curves show the theoretical power that can be transmitted, corrected for the loss due to the centrifugal force, and the shaded areas, the consumption of power by air resistance and mechanical friction. Theoretically, the maximum horsepower transmitted by a rope drive would be when the rope travels at a speed of about a mile a minute (88 ft. per sec.) but the best actual speed is somewhat less than this, being about 75 ft. per sec. or 4500 ft. per min. In Fig. 2 is shown the net power that can be advantageously transmitted at various speeds. Expressed as a formula

$$Hp. = (0.26 - 0.00001073v^2 - 0.00048v)\ vd^2 \quad (1)$$

where v is the velocity of the rope in feet per second and d the diameter of the rope in inches. The results from this formula agree closely with the curves in Fig. 2, which were plotted from actual conditions.

The curves in Fig. 2 and also the horsepower derived from the use of the formula depend on a 180-deg. wrap of rope on the driving sheave and upon the angle of the sheave groove. Cases arise where it is impossible to obtain a satisfactory wrap of the rope about the driving sheave, the apparent arc of contact being less than 180 deg. In such cases, the power transmitted by the driving

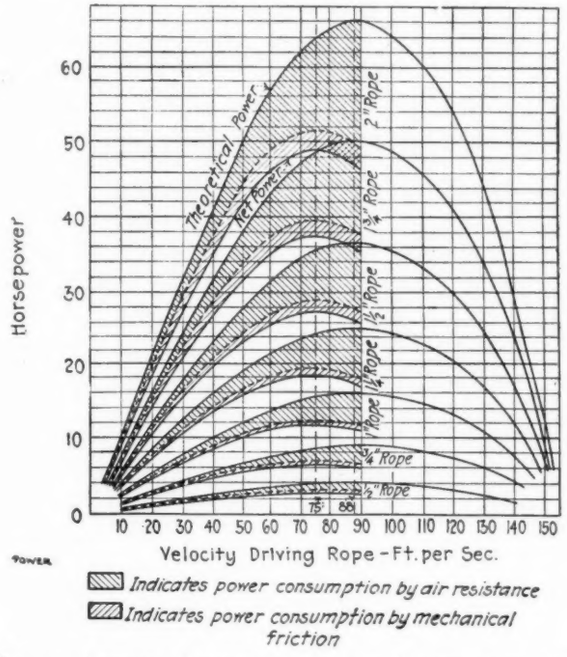


FIG. 1. POWER CONSUMED IN AIR RESISTANCE AND MECHANICAL FRICTION

sheave would be reduced by about one-third of 1 per cent. for each degree of contact less than 180. As a correction factor this may be expressed as follows:

$$B = 100 - 0.34\ (180 - A) \quad (2)$$

where B is the percentage of the maximum power transmitted and A is the arc of contact on the driving sheave. The power-transmitting capacity of drives having an apparent arc of contact over 180 deg. does not increase at the same rate, the effective arc of contact being about 165 deg. for an apparent wrap of 180 deg. Increasing the apparent wrap much over 180 deg. simply necessitates such a degree of snubbing that any gain in power-transmitting capacity is lost in increased friction and unproductive consumption of energy, except in the case of

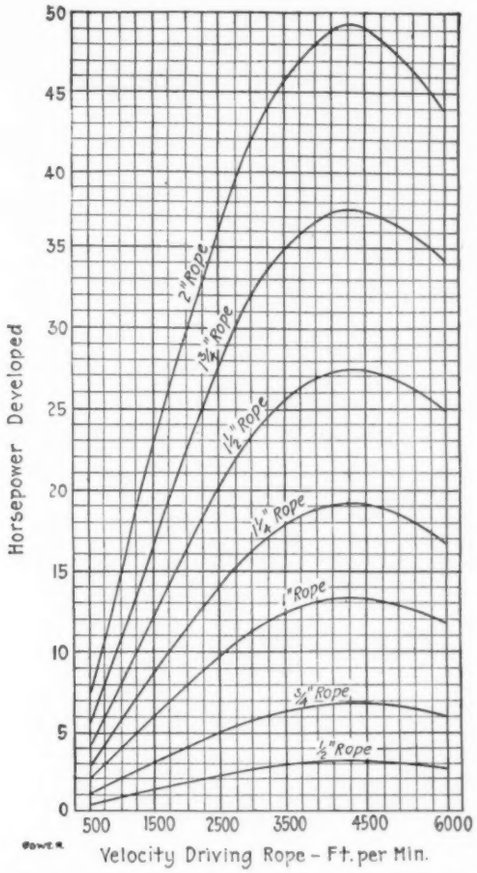


FIG. 2. VELOCITY VERSUS NET HORSEPOWER

very short drives. Should greater accuracy be required, the correction factor may be taken from Fig. 3, which is plotted from experimental data and shows the effect of the arc of contact on power transmission by a sheave with properly proportioned grooves.

The horsepower transmitted by any rope drive, depending upon the difference in tension between the taut and slack sides of the rope, permits the calculation of the tension required in the slack side. Expressed as a formula

$$T' = 75d^2 + 0.0000017d^2V^2 \quad (3)$$

where T' represents the tension on the slack side in pounds when transmitting the full load; d is the diameter of the rope in inches and V the velocity of the rope in feet per minute. Table 1 gives the advisable tension to put on the slack rope, from data derived from actual working conditions. The results from the formula and the data of the table agree very closely.

TABLE I. TENSION ON SLACK ROPE IN POUNDS WHEN TRANSMITTING FULL LOAD

Diameter of Rope Inches	Speed of Rope—Ft. per Min. 1000	2000	3000	4000	5000
¼	20	22	24	28	33
⅜	30	32	35	41	48
½	42	45	50	57	66
¾	58	61	68	77	90
1	75	80	89	101	117
1¼	95	102	113	130	150
1½	118	126	139	159	182
1¾	142	153	168	191	220
1¼	169	180	200	227	260
1¼	198	211	235	267	305
1½	230	245	273	309	358
1¾	263	282	314	356	409
2	300	320	355	407	468

Knowing the tension on the taut and slack sides of a rope drive, it is possible to calculate closely the sag between supporting sheaves. Obviously, the sag on the slack side is considerably more than on the taut side, but

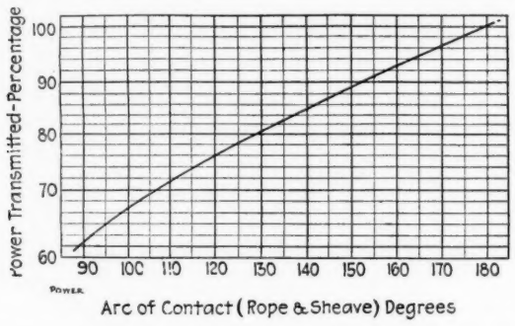


FIG. 3. ARC OF CONTACT VERSUS POWER TRANSMITTED

the driving side is usually the lower side so that more clearance is available for the slack rope.

$$S = \frac{0.3\ L^2}{1800} \tag{4}$$

$$S' = \frac{0.3\ L^2}{600 + 0.0000136\ V^2} \tag{5}$$

where L is the distance between supporting sheaves in feet; V the velocity of the rope in feet per minute; S the sag on the driving side and S' the sag on the slack side.

Formulas (4) and (5) give the proper sag in the driving and slack ropes respectively when the drive is transmitting its full proper power capacity. Table 2 gives similar data obtained from observations under working conditions.

TABLE 2. SAG OF ROPE BETWEEN SHEAVES WHEN TRANSMITTING FULL CAPACITY

Distance Between Sheaves, Ft.	Taut Side All Speeds Ft. In.	Slack Side Running at the Following Ft. per Min. 1000 Ft. In.	2000 Ft. In.	3000 Ft. In.	4000 Ft. In.	5000 Ft. In.
25	0 1¾	3¼	3¼	3	2¾	2½
50	0 5½	1 4	1 3	1 1	11½	9¾
75	1 0¾	2 11	2 9	2 6	2 2	1 10
100	1 9	5 1	4 9	4 4	3 10	3 3
125	2 10	7 11	7 5	6 9	6 0	5 2
150	4 0	11 3	10 7	9 8	8 8	7 6

In taking up the design of equipment necessary for manila rope transmission of power, the most important consideration is the diameter of the sheaves, as it is upon this that the life of an installation and hence its economic value largely depend. The life of a manila rope is not

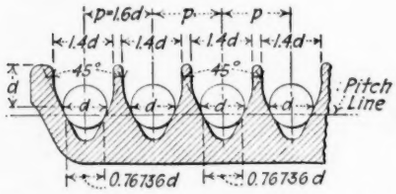


FIG. 4. DRIVING AND DRIVEN SHEAVES

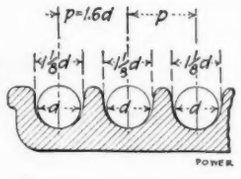


FIG. 5. IDLER AND GUIDE SHEAVE

only dependent upon the degree of bend but also on the number of bends that must be made. The most efficient minimum diameter of sheave for a manila rope traveling at 4500 ft. per min. is about 40 times the diameter of the rope. At such speed, the requirements of the rope are at a maximum and may, therefore, be considered as equal to 100 per cent. At any lower speed the requirements are proportional so that the allowable working stress can be altered accordingly. For instance, at half this speed the rope could be subjected to a working stress nearly twice as great, and as the number of bends that the rope makes is dependent upon both the speed of the rope and the diameter of the sheave, the diameter of the latter need be but half as great as at the higher speed.

Not only are manila ropes used for the transmission of power, but they are also used for hoisting operations where the maximum speed attained under load rarely exceeds 1000 or 1500 ft. per min. and for tackle operations where the rope speed does not exceed 900 ft. per min. Taking the efficient rope speed and diameter of sheave for power transmission as constant, the correct diameter for sheaves for hoisting purposes would be from 9 to 13 times the diameter of the rope, and for tackle operations eight times that of the rope. The relative allowable loads are for transmission purposes, $\frac{1}{32}$ of the ultimate strength of the rope; for hoisting, $^5/_{52}$ to $^5/_{36}$, and for tackle operations $\frac{5}{32}$ of the ultimate strength of the rope. For hoisting there is quite a noticeable variation in the diameter of the sheaves as recommended by different authorities, due to the great variation of rope speeds that may be considered as standard maximums; hence, it is advis-

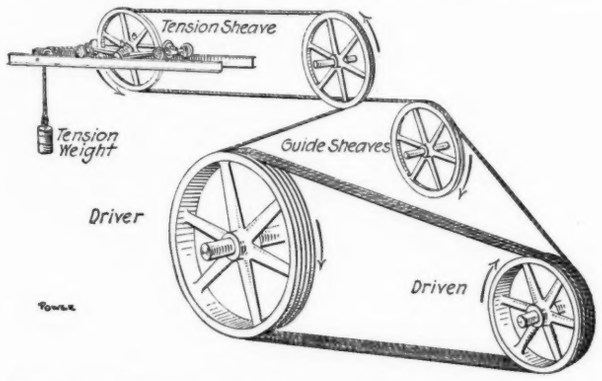


FIG. 6. TENSION TAKEN FROM DRIVING SHEAVE

able to limit the allowable working load for hoisting operations, the rope being subjected to greatly fluctuating loads to about two-thirds that which would be advisable under more uniform and constant conditions of service. Table 3 contains data on allowable working loads and sheave diameters that are considered good practice.

Of almost as much importance as correct sheave diameter is that of proper design of rope grooves. The grooves for both driving and driven sheaves should possess enough gripping power to prevent slippage, but this grip should not be so great as to cause the rope to wedge. Experience

TABLE 3. WORKING LOADS AND SHEAVE DIAMETERS FOR MANILA ROPE

Diameter of Rope In.	Ultimate Strength Lb.	Allowable Working Loads, Lb. Transmission of Power	Hoisting	Tackle	Minimum Diameter of Sheaves, In. Transmission of Power	Hoisting	Tackle
¼	1,800	56	95	280	20	8	4
⅜	2,810	86	160	430	25	9	5
½	4,050	126	252	630	30	10	6
⅝	5,510	172	365	860	35	11	7
1	7,200	225	500	1125	40	12	8
1¼	9,110	285	657	1425	45	13	9
1½	11,250	351	835	1755	50	14	10
1¾	13,600	425	1040	2125	55	15	11
1½	16,200	506	1267	2530	60	16	12
1¾	19,000	595	1514	2975	65	17	13
1½	22,000	688	1780	3440	70	18	14
1¾	25,300	790	1974	3950	75	20	15
2	28,800	900	2000	4500	80	24	16

has shown that the 45-deg., V-shaped groove is the most suitable, the width of the groove on the pitch line being slightly more than three-quarters (0.76736) the diameter of the rope, with a reasonable clearance between the un-

der side of the rope and the bottom of the groove; see Fig. 4. Grooves flatter than 45 deg. are apt to permit slippage when subjected to varying loads or overloads, while grooves with sharper angles are apt to wedge the rope unduly. Theoretically, the flanges of the grooves need not extend much past the center of the rope, but the

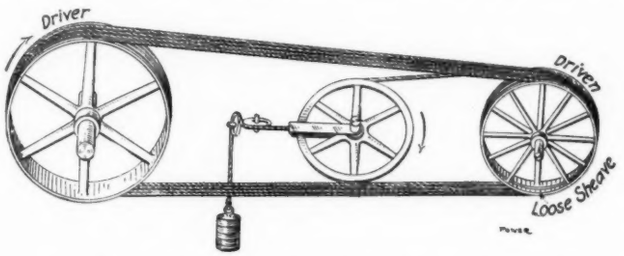
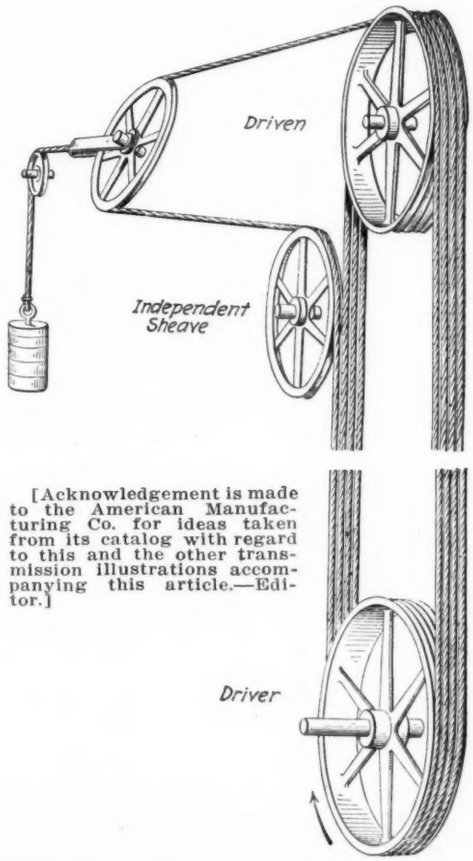


FIG. 7. TENSION TAKEN FROM DRIVEN SHEAVE

possibility of the rope riding up the side of the groove or of increasing in diameter from some cause, makes it poor practice not to have the flanges extend to at least the top of the rope and preferably a short distance beyond the rope. Idler sheaves require grooves that simply support the rope and guide it without any grip; see Fig. 5.

One rope being inadequate to transmit large powers, a number of ropes have to be employed in most cases. This has led to the development of two distinct systems of rope drive, the multiple or "English" system and the continuous or "American" system, both of which have points of advantage so that the choice of system is largely a matter of personal preference and local conditions.



[Acknowledgement is made to the American Manufacturing Co. for ideas taken from its catalog with regard to this and the other transmission illustrations accompanying this article.—Editor.]

FIG. 8. VERTICAL DRIVE, TENSION TAKEN FROM DRIVEN SHEAVE

The multiple system is the simpler, consisting of independent endless ropes running side by side in the grooves of the sheaves, the ropes always bending in the same direction. Each rope in this system is an independent drive in itself and should one break the remaining ones can transmit almost as much power without overloading, so that the broken rope may be replaced at a convenient opportunity. In installations where the power from the main generating unit has to be distributed to several floors or to several independent sheaves, this system is particularly adaptable, as groups of ropes may be led from the driving sheave to any desired point. The main disadvantage of the system is that each rope being an independent unit, the tension in both the taut and slack sides should be about the same for all the ropes. As the various ropes may not stretch equally or be equally durable, more or less continual adjustment of tension is

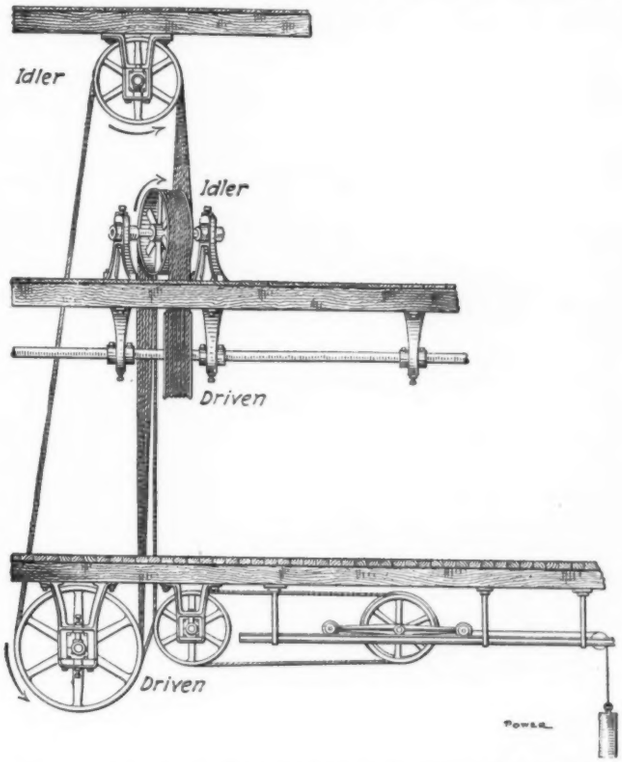


FIG. 9. QUARTER-TURN DRIVE, TENSION TAKEN FROM DRIVING SHEAVE

necessary that they may all do their equal share of the work. However, this fault is not as serious as has generally been supposed, the effective arc of contact between the rope and sheave not varying to any great extent, although the apparent arc of contact may be quite noticeable. The multiple system of rope drive is the cheaper of the two to install and has the longer life of rope because it always bends in the same direction.

The continuous system consists of but one endless rope wrapped about the driving and driven sheaves, the different wraps of rope occupying adjacent grooves. The rope from the inner groove of one sheave must be delivered to the outer groove of the other by passing about an intermediate sheave that transfers the rope from the inner-end plane of one sheave to the outer-end plane of the other. The exception to this rule is when the transfer of rope is made from the inner to the outer, or *vice versa,*

grooves of the driven pulley. The transfer sheave is usually mounted on a tension carriage so arranged as to travel back and forth, producing uniform tension throughout the rope and automatically regulating the slack that may occur from stretch, varying load, etc. The continuous system, more than the multiple system, is adaptable to quarter-turn drives and installations in which the driving and driven sheaves lie in planes oblique to one another, and to complicated transmission installations. Its main and only serious drawback is that should the rope break at any point the whole system is crippled; besides it is more expensive to install than the multiple system. Typical examples of rope drives of the continuous type are shown in Figs. 6 to 9.

The advantages of rope drive may be summed up as follows:

1. The distance over which power may be transmitted is far in excess of that by belts, chains or gearing. Distances up to 150 or even 200 ft. can be spanned without the necessity of intermediate sheaves and if these are used, the distance can be made much greater.
2. The amount of power that can be transmitted is limited only by the number of ropes employed, installations transmitting up to 5000 hp. from one prime mover being in operation.
3. Compared with belting, a rope drive is much more compact and requires less space, the width of a rope sheave is from one-third to one-half less than the width of a belt pulley for transmitting the same power.
4. Rope drives are noiseless if the bearings are properly lubricated, the flexibility and lubrication of the ropes producing their silent running and the air gaps between the ropes preventing any great atmospheric disturbance.
5. Precise alignment of the shafting is not essential in direct drives of any length and drives may take sudden and marked changes of direction if properly placed guide sheaves are employed.
6. Very little slippage occurs in properly installed rope drives, tending to a maximum conservation of energy.
7. Cheapness as compared with belt drives.

Selecting a Pump

By Walter Webster

SYNOPSIS—The computations and considerations by which a volute type of pump was selected from the information submitted by several manufacturers.

A line of artesian wells supplying a tower tank with water through the medium of a triplex plunger pump yields a maximum of 268 gal. per min. Due to the installation of additional manufacturing equipment, a maximum of 675 gal. per min. was required. Test wells proved that no more water was available from that source; city water was considered, but its high cost eliminated the possibility of its use. A near-by river, however, was available, and while it alone could have supplied the requirements, for certain manufacturing processes the well water was preferable. Therefore, it was proposed that the river supply merely the deficiency.

Automatic means requiring minimum attention for maintaining a sufficient quantity of water in the tank was essential. Hence the problem: What was the best method of transferring this water to the tank, operating automatically and utilizing the existing power for the lowest initial maintenance and operation costs in relation to the highest efficiency obtainable?

After consulting a number of catalogs and interviewing several pump salesmen, a volute centrifugal pump was decided upon, since this type seemed best adapted to handling large quantities of water under the conditions stated. Having determined this, the known factors were:

1. Type of pump—volute centrifugal.
2. Head at which pump was to operate at maximum efficiency—80 ft.
3. Length of discharge pipe—610 ft.
4. Capacity—700 gal. per min.
5. Power available—alternating current at 550 volts, 60 cycles, three-phase.

The capacity determined on could supply a trifle more than the maximum requirements; this was to insure unfailing service in case the well pump was under repairs. If the volute pump were crippled city water would be available.

The accompanying diagram illustrates the general operating conditions of the system, from which we had carefully calculated that the pump would operate for a period of 4½ min. approximately five times an hour, and since the demand was not so great at night as during the day, it would operate for a total of six hours out of every twenty-four.

As a result of the conferences with the several pump salesmen, notes were made of characteristics to consider and proposals were requested, submitted and tabulated as follows:

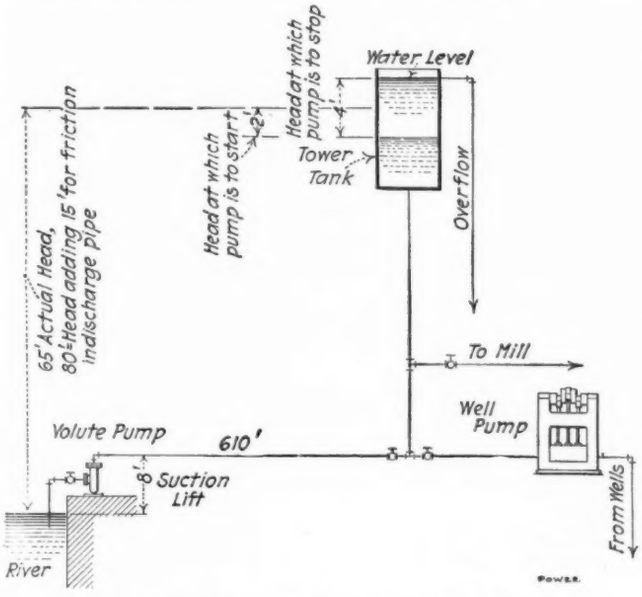
PARTICULARS OF DIRECT-CONNECTED VOLUTE CENTRIFUGAL PUMP

Make of Pump	A	B	C	D	Remarks
Stage	Single	Single	Single	Single	
Suction lift	8′-0″	8′-0″	8′-0″	8′-0″	
Length of discharge pipe	610′	610′	610′	610′	Friction equal to 15′-0″ head
Head in ft. at which maximum eff. is required	80′	80′	80′	80′	
Gal. per min.	700	700	700	700	
Size of suction	8″	8″	6″	6″	
Size of discharge	6″	6″	6″	6″	
R.p.m.	1740	1740	1740	1740	
Casing (type)	split hor.	split hor.	split hor.	split hor.	
Brake hp.	21.74	20.48	21.09	19.63	b.hp. $= \frac{700 \times 8.33 \times 80}{33{,}000 \times \text{eff.}}$
Maximum power under any condition b.hp.	23	21	22	21	
Pump efficiency	65	69	67	72	
Size of motor, hp	25	20	20	20	
Coupling	flex.	flex.	flex.	flex.	
Total weight	2900	2680	2450	2200	
Total cost including electrical apparatus	$ 588.50	$ 576	$ 524	$ 573	
F.o.b. our factory	yes	yes	yes	yes	
Delivery	30 days	45	45	60	

Other points considered in the selection were.
1.—Availability of stuffing box.
2.—Liabilities to leaks.
3.—Wearing parts renewable without renewing expensive parts.
4.—Protection against corrosion.

Maintenance and depreciation charges were considered equal in each make of pump and the choice depended on operating charges, which was decided on a basis of efficiency, the cost of a kilowatt-hour being 2¼c. As a re-

sult of these tabulations, pump A was eliminated at the beginning, due to its high initial cost and lower efficiency. This left the choice between pumps B, C and D. Comparing pumps B and C and converting the brake



Arrangement of Pumps and Piping

horsepower into kilowatt-hours for the six hours per day:

for pump B

$$kilowatt\text{-}hours = \frac{20.48 \times 746 \times 6}{1000} = 91.66$$

and $91.66 \times 0.0225 = \$2.062$ = cost of power for one day's operation of pump B.

For pump C

$$kilowatt\text{-}hours = \frac{21.09 \times 746 \times 6}{1000} = 94.38$$

and $94.38 \times 0.0225 = \$2.123$ = cost of power for one day's operation of pump C. Then, $\$2.123 - \$2.062 = \$0.061$ = Saving in cost of power per day of pump B over pump C.

Cost of pump B = \$576
Cost of pump C = 524

Excess cost of pump B = \$ 52

Then, $\$52 \div \$0.061 = 852$ days pump B would have to operate to pay the excess cost over pump C.

Thus it would require nearly three years of 300 working days each for pump B to pay for its increased cost over pump C, not considering the interest on the additional investment. Therefore, pump B was eliminated, leaving pumps C and D for final choice. Following the same method for pump D,

$$kilowatt\text{-}hours = \frac{19.63 \times 746 \times 6}{1000} = 87.86$$

and $\$87.86 \times 0.0225 = \$1.976$ = cost of power for one day's operation of pump D. Then, $\$2.123 - \$1.976 = \$0.147$ saving in cost of power per day of pump D over pump C.

Cost of pump D = \$573
Cost of pump C = 524

Excess cost of pump D = \$ 49

$\$49 \div \$0.147 = 333$ days pump D would have to operate to pay the excess cost over pump C.

In this instance it was shown that pump D would pay the excess cost over pump C in a little over one year of 300 working days, and would accomplish a saving every year thereafter of \$44.10. Should the pump operate more than six hours per day, which was not at all unlikely, the saving would be correspondingly increased. The choice of the pump was, therefore, conceded to pump D.

In the selection of the electrical apparatus no attempt was made to compare different makes. The reason for this was that since the pump was to operate automatically, reliability was the important factor, and it had been decided to specify apparatus manufactured by a reliable concern that had given us satisfaction in previous installations.

A lesson to learn from the foregoing is, that it is not always the lowest-priced apparatus which is the best to purchase, and unless it is investigated thoroughly, the engineer is likely to use poor judgment in the selection of the apparatus best suited for his particular proposition.

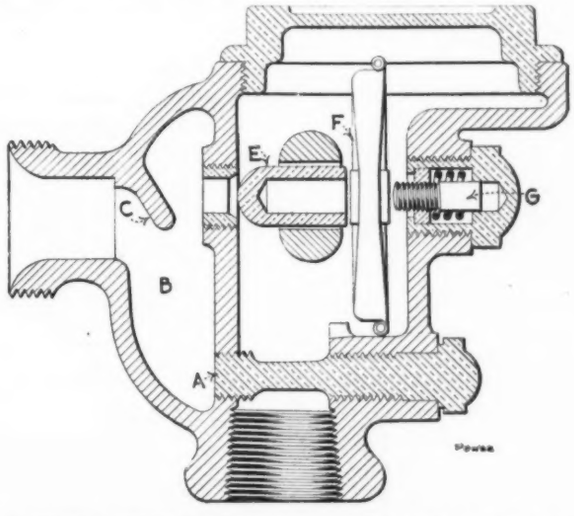
New Monash Thermostatic Valve

The principal enemy of a thermostatic valve is the amount of dirt and sediment in the system; another objectionable feature is the trouble, due to the collapse or rupture of the thermostatic diaphragm.

One feature of the Monash thermostatic valve, illustrated herewith, is that, when steam comes to the valve chamber, the valve *E* closes without any steam pressure coming in contact with the thermostatic member. The diaphragm, being relieved of all pressure caused by steam remaining in the valve case, cannot rupture.

Dirt or sediment cannot pass through the valve opening into the expansion chamber, because there is an ample dirt pocket in advance of the valve seat, with a deflector *C* to throw this dirt and sediment to the bottom of the pocket *B*, from where it can be removed as necessary by the cleanout *A*.

A pocket is provided in the expansion chamber to receive the diaphragm *F*, which is simply dropped in; no adjustment of any kind is required. Provision has been



Section through Monash Thermostatic Valve

made by the use of a spring bumper *G* to take care of the overexpansion of the diaphragm and prevents its collapse.

This thermostatic valve is manufactured by the Monash Engineering Co., 107 West Jackson Boulevard, Chicago, Ill.

Erosion of Boiler-Furnace Arches

By Morgan B. Smith

SYNOPSIS—A method of studying arch erosion by measurement and the results observed in connection with the Roney and Murphy stoker arches.

The method herein described is based upon measurements of the thickness of the arch at definite points after its life has passed, and plotting these measurements upon sketches showing the original contours, thus giving a direct comparison.

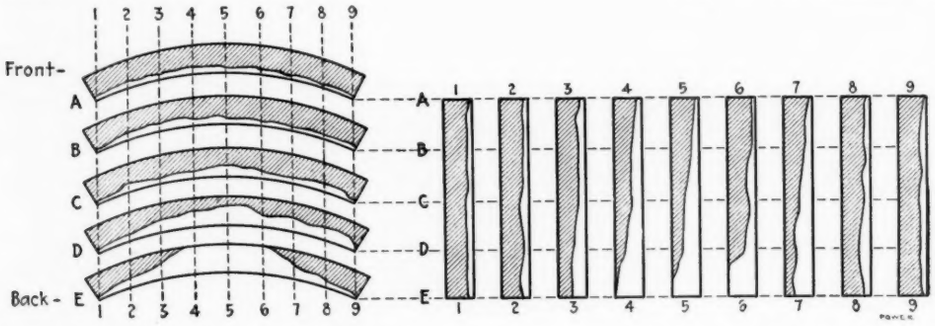


Fig. 1. Typical Erosion of Boiler-Furnace Arches over Roney Stokers with Natural Draft

The first step is to lay off the under surface of the arch, or, in fact, the upper, if such is accessible, into as many parts as are essential, varying with the size. In the present case, five transverse and nine longitudinal sections were made. Measurements are then taken at the intersections of the tranverse and longitudinal lines and charted. They may be taken as the arch is torn down preparatory to building a new one, or, if the arch is in condition to be repaired, from a base line below the arch. The objection to the latter method is that the accuracy is somewhat doubtful because of the likelihood of deformation (settling) of the arch in service, in which case the original measurements cannot be considered comparable with those taken after service.

The arches plotted in the accompanying figures were typical. It has been found that the erosion in one arch over a Roney stoker is similar to that found in other arches over the same stoker; this is also true of the arches over the Murphy stokers, whose typical erosion is quite unlike that shown in those over the Roney stokers. Arches over chain-grate stokers show much the same configuration as those over the Roney.

For brevity, only two types of erosion are shown, with the most marked differences in average contour, due without doubt to the dissimilar design of the stokers. The Roney stoker feeds from the front toward the rear along grates inclined at about 40 deg. from the horizontal, whereas the Murphy feeds from the sides along inclined grates which form a V-shaped fuel bed. In the case of the Roney stoker, the fuel bed is practically a plane surface. The same fuel, Hocking Valley slack, was used under all the arches examined.

Fig. 1, showing the erosion typical in arches over Roney stokers, indicates a remarkably uniform wearing away of the firebrick, the rate gradually accelerating toward the rear of the arch and being maximum at the center. This maximum erosion embraces two full longitudinal sections (4-5 and 5-6) and a portion of one transverse section (D-E). The cause is the concentration of heat at this portion of the arch, the heat taking a converging path from front to rear. This arch was two years and three months old when measured.

Different conditions are encountered in Fig. 2, which shows the erosion typical in Murphy stoker arches. Here there is a zone of comparative freedom from erosion along the center; in fact, embracing nearly all that part between longitudinal-section lines 4 and 6 and transverse lines *A* and *E*. This is most clearly shown in transverse section *D*, in which the action of the gases from the grates at the sides is plainly indicated between longitudinal lines 3 and 4 and 6 and 7. In the last transverse section *E*, this peculiar contour is eliminated, due to the concentration of heat and the increase in gas velocity. The life of this arch was two years and one month.

The data given show that something should be done in the design and construction of furnaces to secure more uniform erosion in service. In the case of the Roney stoker, the problem seems fairly easy, there being two courses open or, rather, three: Thickening the arch at the center toward the back, inclining the whole arch upward

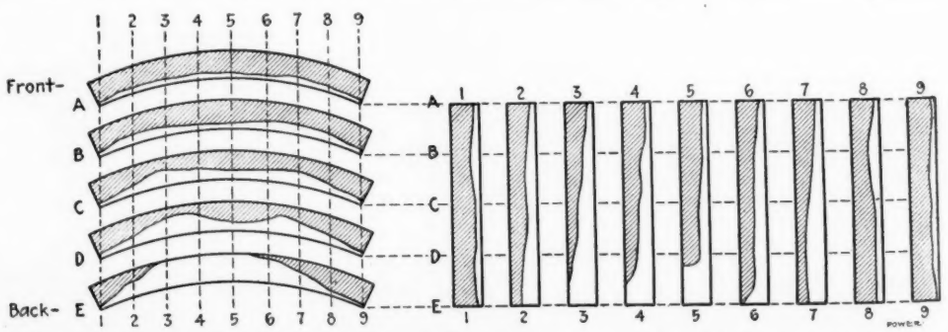


Fig. 2. Typical Erosion of Boiler-Furnace Arches over Murphy Stokers with Natural Draft

toward the rear or, at least, that portion embraced by section lines *D* and *E*, or eliminating the arch entirely. That the last course is feasible is indicated by the fact that to the writer's knowledge two Roney stokers are being successfully operated with no ignition arch whatever, the so called stoker arch being 20 in. in length. The boilers are 500 hp. Stirlings, operating on natural draft with Hocking Valley slack. With this arrangement more economical steam generation was secured than with the regular 6-ft. ignition arch formerly employed.

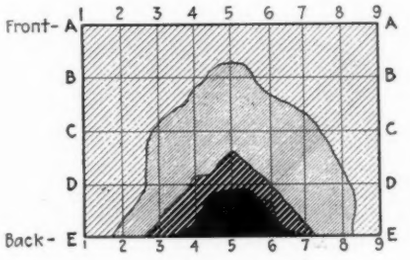


FIG. 3. RONEY STOKERS

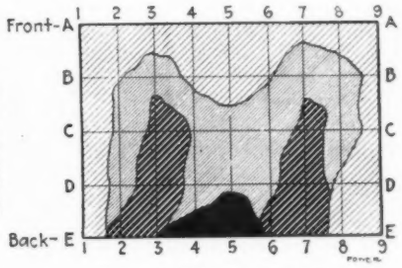


FIG. 4. MURPHY STOKERS

PLAN SKETCHES OF ARCHES SHOWN IN FIGS. 1 AND 2

Figs. 3 and 4 are plans of the arches shown in Figs. 1 and 2, giving the same information in somewhat different form. The paths of the gases along the surface of the arches are shown, and the thought is brought out that there are areas which probably never reach the maximum temperature of the hottest portions. It is evident, therefore, that the arch is under terrific strain all the time, this effect probably being a torsional stress to some extent and accounting for the grinding away of the ends of the arch brick in certain portions.

It is certain that arch design could be advantageously changed so that the paths of the gases would be more uniform over the arch surface and that the heating would, consequently, be more uniform.

Effort in this direction is now being made with some arches of new design under the writer's supervision, but it is too early in their life to state the results obtained. It may, however, be stated that, so far, the results appear to have justified the redesigning of the original arches.

It is likely that the lines of contour in arches over these same stokers but using a different coal, say, a heavy coking coal, would be different from those found in the present investigation. It is probable that in such a case the heating of the arches would be somewhat more uniform and the lines of contour less sharply marked.

Tests of a Small Diesel Engine

In a paper before the Institute of Naval Architects, Professor Dalby presented the results of some tests on a small Diesel engine at the laboratory of the City and Guilds College. The engine was a 6½x10⅝-in. single-cylinder, operating on the four-stroke cycle and nominally rated at 10 hp. Governing was effected by controlling the action of the suction valve on the fuel pump, and in general there was little to distinguish the engine from other types of Diesels.

The figures of the test herein shown are instructive, but the chief interest lies in the indicator diagrams which were taken photographically by an optical indicator. In this indicator no spring or piston is used and the pressures within the cylinder are measured by the slight deflection of a diaphragm connected with a small mirror, which is thus caused to tilt. A second mirror, whose axis is at right angles to the first, receives an angular motion proportional to the piston displacement. A beam of light from within the apparatus falls upon each mirror in succession and is brought to a focus on the ground-glass screen of a camera. When desired, the screen is replaced by a photographic plate.

Interposed between the second mirror and the piston mechanism is an arrangement called a "phase changer," driven from the crankshaft by means of sprocket wheels and a chain. The ratio between this small crank and the connecting-rod is the same as that between the actual crank and the connecting-rod of the engine. This enables the events on the diagram to be changed through any number of degrees. When the phase is changed 90 deg. the "dead point" period is exhibited on a time base instead of a piston-displacement base, so that the variation of pressure in this region can be more closely studied.

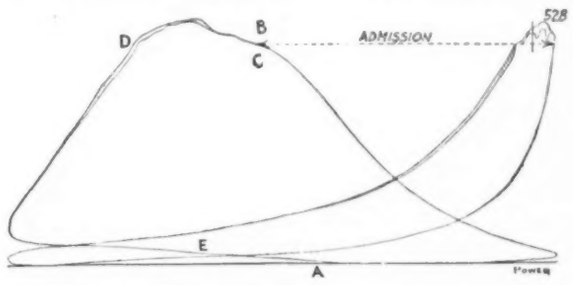


FIG. 1. NORMAL DIAGRAM AND ONE DISPLACED 90 DEGREES

Fig. 1 is such a diagram, the right hand showing the normal diagram and the left hand the same diagram with the events displaced 90 deg. The compression in the altered diagram begins at *A* and extends to the right and up to *B*. At *C* the fuel valve was opened, and the expansion curve begins at *D*, continuing until the exhaust valve opens somewhere near *E*.

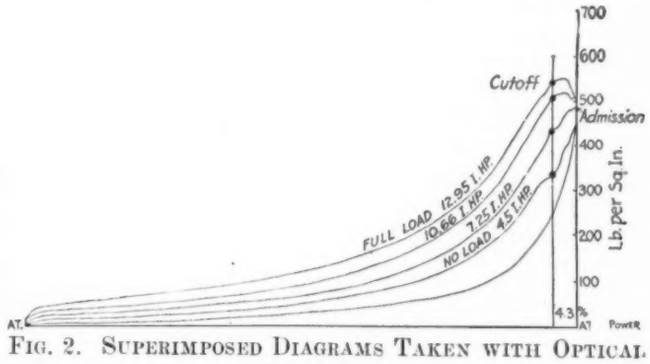


FIG. 2. SUPERIMPOSED DIAGRAMS TAKEN WITH OPTICAL INDICATOR

In Fig. 2 the four diagrams taken at different loads are shown superimposed. The cutoff was the same in each case, being fixed by the cam. It will be noted that

the compression curve is practically coincident for each diagram, and that burning of the fuel takes place at a slightly rising pressure during the full-load diagram. As the load is decreased, the pressure gradually decreases.

RESULTS OF TESTS ON 10-HP. DIESEL ENGINE

	No Load	¼ Load	½ Load	¾ Load	Full Load
Duration of test, min.	60	60	60	60	60
I.hp.	4.5	7.27	10.66	11.69	12.95
B.hp.		3.33	6.71	8.35	9.94
Mechanical efficiency, per cent.		45.8	63	71.4	76.75
Oil per i.hp.-hr., lb.	0.33	0.33	0.34	0.37	0.42
Oil per b.hp.-hr. lb.		0.71	0.54	0.52	0.55
R.p.m.	270	264	259	256	250
Mean effective pressure, lb. per sq.in.	37.6	61.6	92.1	102.9	117.7
Pressure in storage bottle, lb. per sq.in.	875 to 1060	1080 to 1070	1075 to 1095	1100 to 1110	1112
Maximum pressure in cylinder, lb. per sq.in.	469	478	535	529	531
Blast pressure	483	575	675	700	715
Drop of pressure through fuel valve	14	97	140	171	184
Cooling water, lb. per i.hp.	133	93.5	64.5	57	54
Rise in temperature of cooling water, deg. F	12.6	15.3	20.5	23	29.2
Heat equivalent to i.hp. percent. of heat supplied	45	46	44	41	36
Heat carried away by cooling water per cent. of heat supplied	31	26	23	21	22
Heat carried away by exhaust radiation, etc., per cent.	24	28	33	38	42
Thermal efficiency based on i.hp., per cent.	45.3	46.4	44.4	40.6	36
Thermal efficiency based on b.hp., per cent.		21.1	28	29	27.7

Alternate Coal and Gas Firing

It is not often that in stationary steam-boiler installation the need arises for a combination of automatic coal firing with apparatus for burning gas in the boiler furnaces; therefore a brief description of a boiler installation recently erected at the works of the South Staffordshire Mond Gas Co., Dudley Port, Tipton, England, will be of interest.

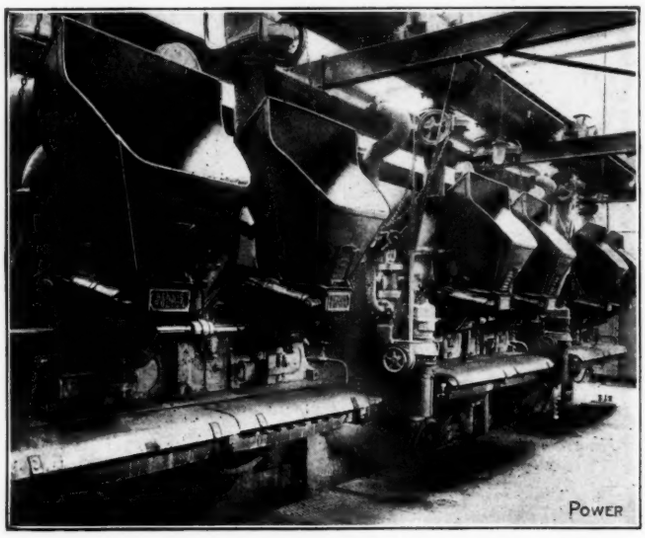
This plant consists of three Lancashire boilers, each 9 ft. in diameter by 30 ft. in length, with extended flues, the boilers working at 120 lb. pressure, fitted with superheaters and with an economizer of 4000 sq.ft. of heating surface. The grate area of each boiler is about 57 sq.ft.

The plant also includes eight producers capable of gasifying 20 tons of fuel per day of 24 hr. and supply gas engines of 2000 hp. capacity. The gas from the producers is washed and cooled, and after the ammonia has been extracted, it is sent through the scrubbers and meters to the compressors and transmitted at high pressure through a system of gas-distributing mains.

The boilers illustrated were at first hand fired, but in 1910 it was decided to substitute mechanical stokers under a guarantee that each boiler would give an evaporation of 12,000 lb. of water per hour, an overload evaporation for short periods of 15,000 lb., and an overall efficiency of 72 per cent. On test the guarantee figures were exceeded, an overload evaporation of 17,000 lb. of water being obtained.

In the operation of the plant it was necessary to keep steam up during the night, and also from the noon hour on Saturday until the start of regular work early Monday morning, and obviously it was advisable to reduce the labor costs as much as possible during this interval. Therefore, gas firing was adopted for night and week-end periods as an auxiliary to the mechanical coal-firing system.

On the top flange of the stoker front, gas ducts are led into the boiler furnace and secured by a gas-tight joint. Baffle-plates are so arranged that a passage is provided having an outlet immediately over the grate for the gas from the ducts to the furnaces there being four ducts to each boiler, two in each flue; each pair is connected by a pipe behind the coal hopper to the gas supply. Air is conveyed to the furnace by means of separate air ducts and does not mix with the gas until it is required to promote ignition inside the flue. A valve with an adjustable cover is placed on the furnace front for regulating the supply of air.



BOILER FURNACES FITTED FOR BURNING COAL AND GAS FUELS

So satisfactory has this duplicate method of firing proved in practice in the two years this installation has been used, that recently, when an extension of the boiler plant was required, the same system was adopted. Careful check was kept on the performance of the plant and during the running test, which extended over six months, under all usual conditions and variations of load, including times when portions of the plant were laid off for cleaning and inspection, it was found that the thermal efficiency was as high as 73 per cent. The average amount of water evaporated per hour per boiler over a month's running was 14,880 lb., when the water was previously heated in the economizer. During this period the boilers were fired in the daytime with slack coal by the automatic stokers and by gas during the night and week ends.

A Demonstration of the possibility of steam raising by the combustion of liquid fuel directly in contact with water has been made in Bremen, Germany. An apparatus consisting of a cylindrical boiler, provided with a number of pockets isolated and drained by suitable valves and drain-cocks, was used. Each of these pockets contains an oil burner, with a pilot burner, by means of which the main burner can at starting be sufficiently heated to effect complete combustion of the oil. When the main burners are well alight, water from the boiler is permitted to flow into the previously drained pockets, and the circulation of heated water commences, the products of combustion as well as the steam generated being used as a source of power in a steam engine.—"Popular Mechanics."

A 951-Ft. Transmission Span—The British Columbia Electric Ry. Co., of Vancouver, B. C., has just installed a new 34,600-volt transmission span over the Second Narrows of Burrard Inlet, to supply energy to North Vancouver and adjacent districts. The span measures 951 ft. between towers and at its lowest point clears the water by a height of 160 ft. in order to permit large vessels to reach industrial plants at the head of the inlet.

Editorials

Ambition

A good thing to have, when the right kind, is ambition. What does it mean? Well, without consulting our Webster, we should say, "Ambition is a desire to succeed." With that as the definition, it is very apparent that the first statement cannot be challenged. Certainly, it is commendable to have a desire to succeed in the right kind of an endeavor. Further, to bring the application home, it is laudable for an engineer to aim to be the best engineer he can possibly be. If he keeps this before him as the goal he wants to reach and does not cease trying for it, he is pretty apt to become a credit to himself and his profession.

So much for the object. Now what is necessary that it may be attained? The answer is "Do not lose your ambition." To the young man, such advice is seldom needed. Youth is a period of hope, and ambition a natural characteristic at that time. The man who has no ambition while he is young is a failure before he starts. Time spent in counseling him is wasted. We are sorry for him, but we cannot help him, so we will dismiss this chap with our pity and turn our attention to another class.

Many, many men, sad to relate, now not so young as they once were, started with high hopes and plenty of ambition, but they have been dropping by the wayside. They got in a rut, became tired and discouraged, and their ambition just naturally died before they got out of the realm of the mediocre. Now they are just plodders. They too are to be pitied, but there is hope for all of them if they can be aroused to the truth that ambition, like muscle, must be exercised, or it becomes weak. Like physical strength, it decreases with age and much more rapidly if it is neglected.

If we were to be called in as a physician to prescribe for this mental ailment—loss of ambition—we should first say take courage as a tonic, your successful friends, who had no more latent ability or educational advantages than yourself, as examples, and practice these exercises:

Begin with a little self-study. Why have you lost your ambition? Certainly not because there is no more that you can accomplish. You are not satisfied. At least, it is to be hoped that you are not, for someone once said that when a man is perfectly satisfied with himself, it is time for him to die. No, you want to get farther along in your work. You want a better position, a better reputation, a larger measure of the world's approval. When you have reached this determination, there is already an improvement in your condition—your ambition is returning. With something to work for, you are ready to go ahead again.

Now is the time to pause to consider what were the influences or circumstances that first dealt your ambition such a body-blow and put a "crimp" in your nerve. Perhaps you were feazed by a sense of your lack of knowledge. The remedy for that is study, and opportunities lie all around you. Pitch in—learn a little at a time. "Every little bit added to what you've got, makes just a little bit more." As you gain knowledge, apply it; then it becomes something real and worth while. The photographic plate may have been perfectly exposed, but it does not amount to anything until it is developed.

Hunt around your plant for the things that are not up to modern standards and do what you can to improve them. Even if you cannot make them better unless the management will spend the money you recognize as necessary, and it refuses to do that, you still have the gain of knowing why they are not right and what right is. You can use this knowledge in the next step upward. Or, if your suggestions are heeded and you are allowed to make the improvements, you will rise a lot in the estimation of your employer.

When your ability has outgrown your present situation, cast about for a better one. Don't wait for it to seek you. Never settle down on any one place as a life job, while there are better ones for which you are fitted or can fit yourself.

Perhaps you will interpose the plaint that you have a family to support and you can not be too independent, etc. That is the very thing that ought to stimulate one's ambition, but all too often is what kills it. If you have a real helpmate at home, she will take a chance for your sake. If she is not that kind, alas, it is a serious handicap, but it is the greater credit to you if you can win in spite of a drag. Many a fellow who got there owes it more to his wife than himself.

Finally, do not be easily discouraged. Be patient over your failures and setbacks, but do not be resigned. Keep some mark in sight, and as each one is reached set a new one. That is ambition and it spells success.

Coal Testing

In line with the preceding editorial, one thing any engineer can do to make himself a better engineer is to test his coal. On page 657 is described a simple, home-made retort for heating and burning coal samples to make a proximate analysis.

The habit of testing the coal as delivered is a mighty good one. Let the coal dealer know you have this habit and he will be more particular to send you good coal. Let your employer know you have it and tell him he can save money, if he can, by getting better coal and he probably will have more respect for you and manifest it in agreeable and substantial ways.

You will need scales to weigh your samples before and after driving off the volatile matter and burning out the combustible. It is not necessary to have an expensive laboratory balance. Scales come in cheap enough forms (good ones can be had for two dollars) for you to afford them out of your own pocket if necessary, though it probably will not be left for you to pay for them when you have explained what you want them for.

Take the ash determination, for instance, just divide the final weight, deducting the weight of the crucible, by the first weight, less the crucible weight, point off two places in the answer and you have the percentage of ash. If it is over, say eleven per cent. for anthracite, sixteen per cent. for bituminous, and twenty-two per cent. for slack, you may know that you can get better coal, and probably should. However, the cost of the coal is always to be taken into account. Sometimes a poor coal is enough cheaper than coal a little better to be more economical in the long run. This presupposes that the furnace conditions are right for burning the poorer coal. In any event, do not neglect consideration of the added labor and more rapid destruction of the lining, if they prove to be the consequences of burning the poor coal.

With each new grade of coal tried, it is well to make a complete proximate analysis. After that an ash determination will show about what to expect and whether subsequent deliveries are up to the first one that got your dealer his order.

By the way, bear in mine the idea that is being taken up so rapidly—of buying coal on specification. We have printed considerable on the subject lately. There are tremendous possibilities in the practice. It is not unlikely that you may find it of advantage in your plant.

Boiler-Furnace Series

Closely akin to the subject of coal, just referred to, is the matter of how it is burned. In this issue is printed the first of a series of articles relating to the construction of boiler furnaces by Osborn Monnett, smoke inspector of the city of Chicago. This one is entitled "Gas Passage in Return-Tubular Boilers" and, as explained in the synopsis at the head of the article, applies to the use of Middle West bituminous coals. Many of our readers are dealing with just these kinds of coal and will find helpful information in this discussion.

Other installments to follow will treat of the arrangement of baffles and dampers and the design of uptakes and flues, etc. Two or three will deal particularly with draft. Number seven in the series will be entitled "Analyzing an Existing Plant" and should be specially interesting to those who feel that their equipment could give better results, but do **not** know just where the faults lie. Another later installment will be of value to everybody, as the title alone shows, "Rules for Firing without Smoke." We are not disposed to show any more of our hand now, but we will say this: "We have a fist full of trumps."

Presenting this series at this time is in keeping with our plea for more attention to the boiler room. It has not been getting its share as compared with the parts of the plant where the steam is used. "Saving at the spigot and wasting at the bung" is what every plant is doing that strives for the most economical steam consumption without regard to the wastefulness of the steam production. In the total efficiency from coal to power, by far the greatest loss is in the boilers and furnaces. A little saying here can offset a big lack of economy in the engines or turbines.

We sincerely trust that these articles will be read with profit by a large part of our readers. They will be well worth thoughtful perusal, and we hope that they will not only be read and digested, but that they may be the means of greatly improved conditions in very many plants. We take not a little satisfaction in having secured these articles from so eminent an authority as Mr. Monnett. He has done and is doing splendid work in Chicago, and when he went to that field from the editorial staff of POWER, what we lost was Chicago's gain.

Introducing Will Quizz, Jr.

Gentlemen, shake hands with Will Quizz, Jr., who makes his first appearance "in our midst" on page 666. He is a fellow you all know well. A human interrogation point, and found in nearly every power plant. To some, he seems a pest, but he really is a benefit because his observing and critical disposition keeps the chief on the alert. And so it is with his boss, Chief Teller, the other principal character in this series of articles that will appear in POWER as often and for as long a period as they seem to be welcome. Incidentally, Teller is the kind of a chief we were pleading for in the editorial, "Helping the Helper" in last week's issue.

The purpose of the series will be to take up questions that bother the younger fellows particularly, who are just being broken into the power-plant harness. Obviously, therefore, these articles need not be expected to be very profound, but we do hope that they may prove a pleasant, easily assimilated way to administer a little information on some commonly misunderstood questions—sort of sugar-coated, as it were. Treated in the conversational or correspondence manner, it is the object to add the element of human interest and so make an ordinarily dry description a little easier reading.

In this way some questions that cannot be adequately covered in the briefer answers, we are compelled to give on the "Inquiries of General Interest" page may be taken up by "Will" with "the Chief" in more detail. We can not promise to use every question sent in for this treatment, but as the purpose of this series is to help the perplexed readers, we invite suggestions as to subjects, or contributed installments.

Speak Up!

The year's test at the New York City Hall of Records ended last December. Five months have now elapsed and the engineering fraternity is still anxiously awaiting the verdict.

As far as the test itself is concerned, the report has been completed and submitted. The matter is now in the hands of the advisory committee, which will determine the fixed charges. One is led to inquire, and with apparent justification, why the committee has taken so long to arrive at the fixed charges. What were they doing while the test was in progress? Surely, a year was ample in which to decide these charges, so that they could be submitted simultaneously with the final results of the tests and thus expedite the complete report.

As we have pointed out before, the affiliations of different members of the committee would indicate a division of opinion as to the fixed charges and we should not be surprised to see this result in a majority and a minority report. Whatever the outcome, let there be no more needless delay, for, in the eyes of the public, unexplained delay creates suspicion, even though it be unfounded.

Correspondence

What Did the Engineer Get?*

The cry that W. H. Odell puts up, in the issue of Apr. 14, is the same one many another man has adopted for his standard, i.e., "Look after the condition of your own pocketbook!"

Let me say, there are several ways of looking after your pocketbook, but only one legitimate way, and that is to give your employer the best service that is in your power.

If Engineer Wise could save $7030.40 per year for the company, it was his duty to do so. When an engineer enters the service of a company he should work for its interests in all things. If Engineer Wise had allowed the conditions in the plant to remain as they were under the former engineer, do you think he would have been giving value received for his salary? It is all very well for us as engineers to criticize our brother workmen and our employers, but there are two sides to every question, and one of them is our employer's. If I deliberately let $7030.40 (or any part of that amount) of my employer's money go to waste, I am not entitled to the name of engineer. Such men are a big asset to the central-station company, as they make it impossible for the isolated plant to exist.

Getting down to the "How about it?" in the article: If Engineer Wise had gray matter enough to see where the leak was, and had the moral courage to stop it, he demonstrated that he knows his business. As soon as you can do that for any employer your salary is not a question of dollars and cents; you are an asset in his business, and the salary will adjust itself according to your ability. That is all the "How about it?" there is to it.

O. Newton.

Cleveland, Ohio.

The question brought up by W. H. Odell, in the issue of Apr. 4, on page 528, has been asked in other cases. The answers usually intimated that the engineer who is only in the business for the money he can get out of it will never make a high-class engineer; that his heart and mind should be so absorbed studying theoretical and practical problems that expecting to get or even thinking about money should be a minor consideration.

Advice is handed out to persevere onward and upward on the path of knowledge, and ultimately your worth will be noted, Success will grab you, and you will then have the earth at your feet, placed there by the god Success, for you to kick where you list. You know better! Study and experience are good, the best in the world; get all you can, as you cannot get too much of either. But when by your knowledge you succeed in saving your employer's money, do not neglect to let him know it. Tell him that you have used up your time, money and energy in making yourself a valuable man, and that you expect pay for it.

An engineer is unjust to himself, to his family and to other engineers if he does not see that he gets what his services are worth. Do not attempt to put coin in your pocket at the unauthorized expense of your employer. Graft in any shape on goods used in your own plant is simply sneak-thief stealing. If you pay yourself by robbing your employer, you are only lowering yourself, and the boss who will underpay his employees is much the same. It is a good plan when starting on a new job to ask your employer if he will allow you a percentage of the saving you can make, always providing that you give as good or better service than he has been receiving.

However, it is your duty to do your best for your employer whether he pays you extra for it or not. He is only compelled to pay you what he promised, but when you do take a job at any salary, big or small, give your employer the best you have to give.

James Thorn.

Toronto, Ont., Canada.

W. H. Odell wants to know what I got for looking after my employer's coal pile as well as my own interest. I got a check for $100. The saving on coal is only about half of the total savings per year. There is the saving on packings, oil, etc., and all outside shop bills; all overtime and Sunday work were cut out. The increased production is due to the many changes I have made. It is impossible for me to get the exact figures of the output from the firm, so I asked the foreman of the mill room how the output now compares with what it was when I took hold four years ago. He said it had increased about five times, judging from the orders got out then, and now.

I know that we are doing more work, because we have quite a time getting orders filled, working until nine o'clock three nights a week.

Readers may want to know why I do not quit. Well, I probably would if I could get a position which would pay me more than I am getting now. We hear a lot about competent men being at a premium. I must be very incompetent. I quote a few of my experiences in looking for a better-paying position. I tried for one as chief engineer in a printing plant. The manager told me that the engineer they had was not competent, that they paid him $35 a week; that there were ten men in the department, and that the plant was in bad shape. Would I take the position for $25 a week, discharge four men and get the plant in shape? Then they would consider what I was worth. I declined the offer. Next I put in an application for a 3000-hp. manufacturing plant, and was asked if I had ever had charge of stationary plants as large as that. I had not, so I was judged not competent to fill that position. My next endeavor was in the office-building line. Had I ever been in charge of an office building? No, again. I was not thought competent.

*"Power," Mar. 10, p. 346; Apr. 21, p. 561.

So here I am, open for any position that will pay me the money I want. Until I can do better, however, I will stay where I am until the bank account and the family have grown large enough for me to quit for good.

C. H. WISE.

New York, N. Y.

Operating a Powdered-Coal-Burning Boiler

After reading the article by William A. Evans on "Powdered Coal in Boiler Furnaces," readers will probably like to hear something about the Bettington boiler in actual service.

It is unfortunate that, having brought the Bettington boiler to its present state of efficiency, Mr. Bettington should have lost his life while making an aëroplane flight in England, about 18 months ago, and left still unsolved so many problems connected with the use of powdered fuel.

For about two years the writer had two Bettington boilers under his charge, and so had ample opportunity to study this type under working conditions.

Some auxiliary source of power is necessary for working the pulverizer while steam is being raised. This, of course, presents no difficulties in a large plant, but it might embarrass the use of the boiler in a small plant.

Igniting the fuel is a simple matter. A specially devised lighting torch using kerosene is placed just over the outlet of the fuel pipe, and the pulverizer started. In a few minutes the fuel ignites and the torch is withdrawn. The circulation is rapid in the Bettington boiler and steam is quickly raised. The writer has known the boiler to be "cut in" with a pressure of 150 lb. gage 30 min. after the torch was applied, the temperature of the water in the boiler being about 65 deg. F. when starting. Owing to the rapid evaporation and the limited water space, the water gage-glass must be closely watched. If the feed water is cut off the water disappears from the glass in a few minutes.

Damp coal must be avoided or the screens in the dust-separating chamber or carburetor will choke up and prevent any feed passing to the furnace.

The pulverizer also acts as a fan, the air and fuel being intimately mixed in the dust chamber. The fuel and the air supply can be regulated independently. Peepholes allow the state of the flame to be seen at any time. One point that must be carefully watched is the dished plate which forms the bottom of the top header. By referring to Fig. 6, page 472, of the Apr. 7 issue, the reader will see that this plate forms the top of the combustion chamber and is subjected to a fierce heat. It must be kept clean; in one case this plate was burned through, probably owing to dirt collecting there.

Although this boiler will use low-grade fuel successfully, this advantage is greatly offset by high cleaning and maintenance charges. Firebrick of a special shape is used to surround the inner row of tubes and form the combustion chamber. In spite of the cooling effects of the tube, these bricks are quickly burned away and frequent renewals are necessary. The brickwork should be closely inspected at every opportunity or holes will be burned through and the gases short-circuited to the chimney. The heaters and liners of the pulverizer are subjected to rapid wear and tear, and call for frequent repair and renewal. While under steam the boiler is easily managed, and one fireman can look after several boilers without any trouble.

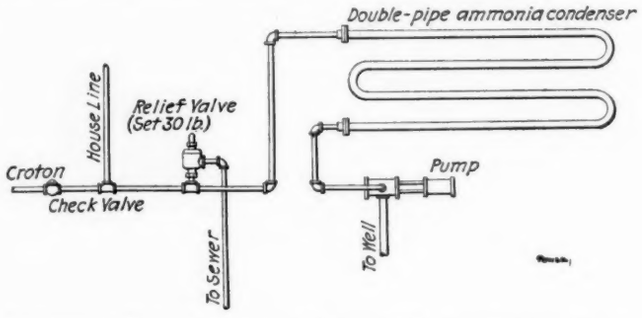
The Bettington boiler has certainly gone a long way in solving the problem of using powdered fuel, and we may expect to see big developments in this direction during the next few years.

HENRY E. BRENNAN.

Quartz, Ont., Canada.

Ammonia Condenser Water for House Purposes

Our ice bills for the last few seasons were so high that it became necessary to install a 15-ton plant. After the plant was completed, the question arose of getting water for the condenser. Croton being too expensive, I suggested that we bore a well; this was done without delay.



AMMONIA CONDENSER AND HOUSE-WATER CONNECTIONS FOR WELL WATER

The condensers required about 30 gal. per min., which we had to let go into the sewer. Formerly we used Croton water mostly for flushing purposes, and our water bills were about $1000 a year.

I was asked by the management to devise some plan by which we could use our well water for flushing. I first thought of installing a tank on the roof, but while getting the estimates I tried out another idea, as shown. This plan is working perfectly, with but little expense to install and at any pressure desired.

GEORGE ZIMMER.

New York City.

Pier in Furnace Lowers Evaporation

The smoke department of a city in the Middle West got after a plant that was violating the smoke ordinance. So persistent was the department that the owners got tired of reading letters, and on the advice of their chief engineer wrote the inspector that they had installed the kind of a stoker he had recommended when they built the plant; and inasmuch as they had complied with his recommendations it was now up to that office, but if he had any suggestions to make, they would be pleased to consider them. Up to that time the evaporation had been good, being from 8 to 9 lb. from and at 212 deg. F.

Here is what the smoke department suggested: That they build two piers on the bridge-wall and one midway between the bridge-wall and the back end of the grates, each pier to be 24x24 in., and to extend up to the bottom row of flues. The company acted on the suggestion, and

after the piers were built it got the approval of the smoke department.

Then the boiler was put into service, and the evaporation dropped about 3 lb., or from 8 to 9 lb. down to 5 to 6 lb. The object of the piers was to give the gases a rolling motion and retard them by holding them in the furnace until burned. The temperature in the dutch oven ran above 3500 deg. F., while in the breeching it was only 480 deg. F., with a draft over the fire of 0.27 in. and of 0.48 in. in the back combustion chamber. As much as 13 per cent. CO_2 was obtained with the automatic damper closed. The steam pressure carried was 125 lb. After all these readings were taken several times to make sure that they were correct, it became evident that there was something radically wrong. A systematic investigation was made, and then the chief came to the conclusion that the piers were the cause. Unknown to the smoke inspector, the engineer removed the center pier, leaving the two on the bridge-wall, thereby allowing the hot gases a freer passage.

The result is the evaporation now runs 7 and 8 lb., the draft over the fire, 0.32 in., the draft in the back combustion chamber, 0.54 in., the temperature in the dutch oven is 2800 to 3000 deg. F., the temperature in the breeching 540 deg. F., with a CO_2 reading of 12.4, and the smoke is eliminated.

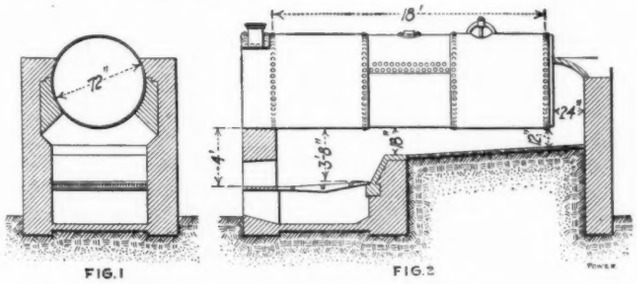
O. Newton.

Lakewood, Ohio.

Boiler Setting for Burning Wood

Our plant serves a wood-working establishment. We had a 72-in. by 18-ft. horizontal tubular boiler to be set for burning wood, and while it is always customary to set boilers further from the grates for wood than for coal, in this case we set the boiler as shown.

Fig. 1 represents a front and Fig. 2 a side elevation of the setting. It will be seen that the grates were set 3 ft. 8 in. at the back end from the boiler shell, with a 4-in.



Setting for Burning Wood Fuel

drop toward the fire-door, making them 4 ft. at the front end from the boiler. The bridge-wall is 18 in. from the shell, and the back of the combustion chamber 12 in. from the boiler. The aim with this style of setting was to create a "scrubbing" contact on the shell. Wing walls were built at the back end of the boiler to baffle or retard the flow of the gases.

There was much criticism of this furnace by the local engineers, but a few weeks after it was started we found that the wood could be sold to advantage. Then we began burning coal. Many predicted that we would surely have to change the furnace, but we continued using coal with better results than are obtained with boilers having lower settings.

We did not determine the percentage of CO_2 in the gases, but I feel confident that it was high. The test showed an evaporation of 8¾ lb. of water per pound of coal.

H. R. Rockwell.

St. Louis, Mo.

Electric-Crane Troubles

A piece of apparatus which often does not receive the proper attention is the electric crane. Some persons are under the impression that almost anyone can operate and take care of an electric crane, which, however, is not true. It pays in the long run to have an experienced man in charge. An inexperienced or careless operator may ruin the motors, the bearings and the other apparatus on a crane in a short time. In large manufacturing plants, where there are a number of cranes in use, it is good practice to place all the crane operators under the charge of one man, who may be the chief engineer.

In many plants the crane runway is not kept in line, the flanges on the bridge wheels are worn off and much power is unnecessarily wasted, besides the wear and tear on the crane.

Where crane motors have run for a number of years, the bearings should be examined to see if they are worn. Allowing the armature to rub against the field coils, if not noticed and repaired in time, may ruin the armature as well as the field coils. Worn bearings on a motor will cause other troubles as the armature and commutator will not run true and the brushes will not make good contact at all times, resulting in sparking.

The motor which drives the bridge on one of our cranes started to spark one day and at times it would not carry the load. At first it was thought that there was a short-circuit in either the armature, the commutator or the field coils. When these were examined and tested they were found to be all right, and it was later discovered that the bearings were worn, also the commutator was worn out of true. Upon renewing the bearings and turning down the commutator, the trouble ceased.

Some operators have a habit of sandpapering the commutator by holding a piece of sandpaper on with nothing but the hand. As a result the commutator is apt to have an uneven surface and there will be more or less sparking at the brushes. When it is necessary to sandpaper the commutator the sandpaper should be held in place by a piece of wood rounded to fit the commutator. If the commutator is very rough a fine sandstone will give better results.

Still another bad practice, when sandpapering the brushes, is to remove the brushes from the holders; the proper way is to leave them in the holders and place the sandpaper under the brushes, then pull forward and backward.

Some operators are careless in sandpapering the contact points on the controllers. They do this work by holding the sandpaper in the hand and rubbing forward and back over the contact points. In a short time the contact points will have an uneven surface, and it will be impossible to prevent the fingers from sparking when passing from one contact point to another. I have seen controller contact points sandpapered in such a careless

way that the heads on the brass screws, which hold the contact points in place on the controller plate, were nearly worn away from the sandpaper. It is better to lay the sandpaper on a piece of wood which has a flat, even surface, then there is not the danger of wearing some parts of the contact points more than others.

With cranes in places where there is much dust and foreign matter, the armature-field coils and the controller should be cleaned out frequently with air under pressure. While most crane motors are of the closed type more or less dirt usually finds its way into them.

On some electric-crane motors the tension on the brushes is maintained by small coiled springs placed on the brush-holder, but which are not adjustable. At times these springs become weak and slight jars will lift them partly from the commutator, and sparking results.

The bridge motor on a crane would not start. It was discovered that there was no current at the motor with the controller lever in starting position. After examining every part and following up the wires from the motor to the collector shoes, it was found that one of the wires leading from the collector shoe to the motor was broken off at the shoe terminals, but in such a way that it could not be easily detected.

In another case, the trolley-drive motor on a crane located outdoors would not start. Nothing was wrong with the motor and conections, but there was no current at the motor with the controller lever in running position. Then the collector shoes at the trolley wire were examined more closely, and it was discovered that there was ice between the bottom of the collector shoe and the trolley.

H. A. JAHNKE.

Milwaukee, Wis.

Adapting Fan to Boiler Loads

The writer recently had a peculiar experience with the installation of a forced-draft system for four horizontal tubular boilers which illustrated the importance of the proper relation between fan capacities and load requirements for installations of this kind.

An effort was made to use an old fan the customer had on hand, but of which no exact capacity data could be secured. Provision was made, however, that if the fan proved unsuitable, one of standard design and of known capacity could be substituted.

The customer's fan was of the high-speed, multiple-blade type, directly connected to the steam turbine. When the system was installed and the boilers were fired, we found that we were unable to carry the ordinary load, evidently not developing the capacity of the boilers, although we had a very hot fire on the grate. After much experimenting by changing the fan speed, reducing the speed of this type decreased the pressure more rapidly than it reduced the capacity, and by the time we had the proper quantity of air it was furnished at such low pressure that the fires would deaden.

We then foolishly tried speeding the fan to get a pressure of about 1 in. of water, and attempted to restrict the quantity by throttling the intake of the fan; this was our only recourse without suspending operations to do some work. Naturally this produced no result except that it increased the speed of the air in the suction intake.

After working through the day with considerable difficulty to carry the load with a CO_2 percentage running from four to eight, we had the brick duct from the fan to the boiler opened during the night and a sliding opening made, so that we could run the fan at the reasonable pressure and waste a part of the air.

The next morning we took a CO_2 analysis with the slide closed and secured 4 per cent. Immediately afterward, by opening the slide, the percentage of CO_2 jumped to 14.

In a short time we were able to cut out one boiler and carry the load with three. We operated the fan in this way for about a week, or until we could secure a fan of the proper size. This plant is now running with a saving of about one-third less fuel than was used with the practice prior to the making of this forced-draft. hand-fired installation and the removal of the stokers.

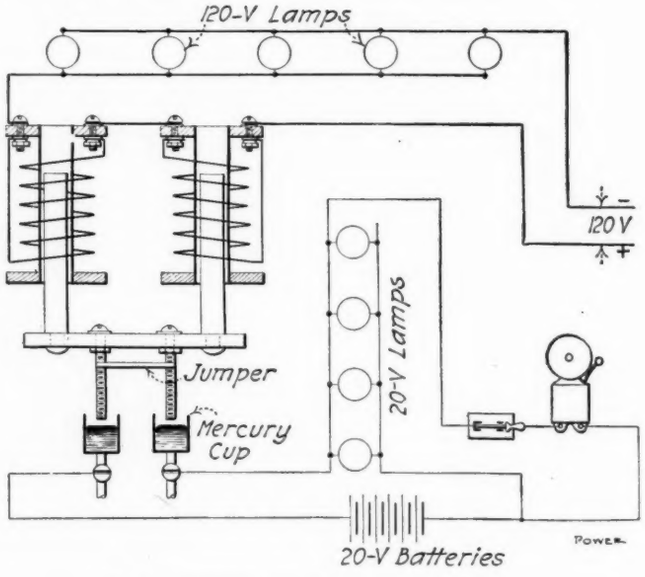
J. H. DIETZ.

Cleveland, Ohio.

Emergency Lighting Switch

On several occasions I have had the circuit-breaker go out and leave the plant in darkness, so I concluded to rig up an emergency lighting circuit which would automatically come into use when the circuit-breaker tripped or the voltage dropped an appreciable amount. For this purpose a 20-volt, 15-ampere storage battery, ordinarily used for our bell circuits, was employed and a switch devised as shown in the sketch.

The switch consists of two solenoids in series and in circuit with five lamps across the 120-volt line. These



CONNECTIONS OF EMERGENCY SWITCH

lamps take 2½ amperes collectively, which current is necessary to operate the solenoid. Attached to the yoke of the solenoid are two brass screws, connected by a jumper and thoroughly insulated from the yoke.

When the circuit-breaker goes out or the voltage drops below a certain value, the solenoid drops and the two screws complete the battery circuit through mercury contacts. Thus a number of five-watt, 20-volt lamps are lighted at convenient places in the engine room. There is a bell in parallel with the lamps and when the switch is closed and the solenoid operates, the bell will ring also.

WILLIAM PATTERSON.

New York City.

Inquiries of General Interest

Gasoline Engine Release Pressure—What is the pressure at release in a gasoline engine?

W. T. O.

It depends largely upon the timing of the exhaust valve and the explosion pressure, which, in turn, depends upon the mixture and upon the compression pressure and upon the load. With full load the pressure at release may be as high as 40 to 50 lb. per sq.in. At lighter loads it will be much less, the amount depending upon the factors mentioned.

Air Chamber on Suction Line—What is the purpose of placing an air chamber on the suction side of a pump?

J. R.

Where a pump suction is supplied under pressure and especially when a single-cylinder pump is used, an air chamber in the suction line near the pump is useful in affording a cushion for absorbing the shock of water hammer which results from suddenly arresting the velocity of water in the suction line at the end of each stroke of the pump.

Flow of Steam through Nozzle—How much steam at 120-lb. boiler pressure would be discharged per hour into the atmosphere through a nozzle having an aperture ½ in. in diameter?

C. J.

Napier's approximate rule for discharge of steam is: Flow in pounds per second = absolute pressure × area of aperture in square inches ÷ 70. As the pressure would be 120 + 14.7 lb. per sq.in absolute, and the area of ½ in. diameter is 0.19635 sq.in., then the discharge would be

$$\frac{134.7 \times 0.19635}{70} \times 60 = 22.67 \text{ lb. per min.}$$

Automatic vs. Mechanically Operated Valves—What are the relative advantages of automatic and mechanically operated valves in a gas or gasoline engine?

R. G.

Automatic valves cannot be timed, are more likely to stick, and in fast running engines must be made light and, consequently, weak. They are cheaper than mechanically operated valves, and where lightness of weight is desirable, as in aëroplane engines, automatic valves may be employed to advantage as they require neither push rods nor camshaft gearing.

Concrete Blowoff Sump—Can a suitable blowoff tank be constructed of concrete?

L. A. B.

Concrete would be suitable for constructing the bottom and side walls of an open sump or basin for holding and cooling blowoff water before discharging it to a sewer or other point of drainage. Such a sump should be fenced and placed outside of buildings and at a safe distance from foundations that would be injured by seepage from the sump which would be likely to result from cracks in the concrete due to unequal expansion when heated by the blowoff water.

Using Exhaust for Heating More Than Feed Water—Can more than one closed exhaust steam heater be connected with the exhaust of a noncondensing engine, and obtain heated water in excess of boiler-feed water required for generation of steam used by the engine and ordinary power-plant auxiliaries?

T. D. T.

Yes; by using a feed-water heater containing a proportionate amount of heating surface or connecting several feed-water heaters of sufficient size, it is practicable in most plants to utilize the exhaust in heating to the same temperature, four or five times the quantity of water required for boiler feeding.

Expression for Inductance—How is the term $2\pi f$ in the expression for inductance, $2\pi f L$, related to the flux cut per second?

F. G. K.

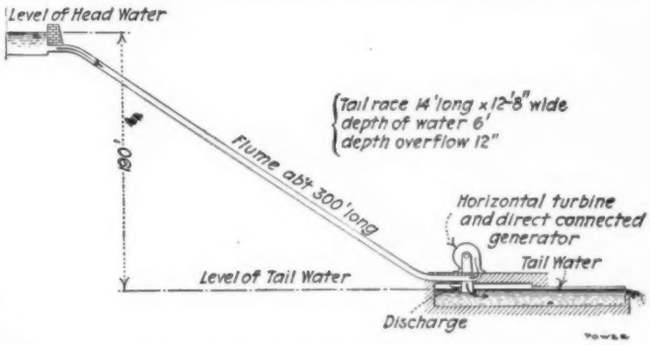
The electromotive force of self-induction depends upon the rate at which the magnetic lines of force change, and hence upon the rate at which the current changes. The maximum rate of change per cycle is 2π times the maximum current, and if the current passes through f cycles per second the rate of change of current in amperes per second will be $2\pi f$ times the maximum value of the current. If only one ampere is considered, the rate of change would be $2\pi f$. This multiplied by L, the coefficient of self-induction, gives the induction of the circuit.

Too Much Pipe Friction—Why does a pump which will raise water with a vertical suction lift of 25 ft., fail to operate when connected to the top of the vertical suction pipe by a tight suction line extended horizontally a distance of about 300 ft.?

C. W. R.

Lifting by suction is accomplished by the pressure of the atmosphere which at sea level would balance a column of water about 33 ft. high; but in the operation of a pump with suction lift, in addition to the actual head overcome, the atmospheric pressure is employed in overcoming frictional resistances to the entrance of the water into the suction pipe, in overcoming air leaks, in creating velocity of flow, in overcoming pipe friction and friction of pump passages and in overcoming the pressure of air or vapor in the pump cylinder. Under the conditions stated, by extending the suction pipe 300 ft. additional resistance of pipe friction is introduced and a suction supply to the pump cylinder cannot be maintained because the sum of the resistances to flow have become too great to be overcome by the pressure of the atmosphere.

Efficiency of Hydro-Electric Plant—A hydro-electric plant has a direct-connected generator connected to the shaft of a horizontal water turbine. As shown by the sketch, the head water has an elevation of 190 ft. above the level of the tail water when the plant uses 50 cu.ft. of water per second,



and develops 480 kw. What is the water horsepower and the overall efficiency of the plant?

B. J. L.

One kilowatt equals 737.3 ft.-lb. per sec., and the net output would be

$$480 \times 737.3 = 353{,}904 \text{ ft.-lb. per sec.}$$

As a cubic foot of water weighs 62.36 lb., the water used would be

$$62.36 \times 50 = 3118 \text{ lb. per sec.,}$$

and as the total head is 190 ft., there would be

$$190 \times 3118 = 592{,}420 \text{ ft.-lb. per sec.}$$

developed by the water.

As 1 hp. $= \frac{33{,}000}{60}$ or 550 ft.-lb. per sec., there would be developed:

$$\frac{592{,}420}{550} = 1077.1 \text{ water hp.}$$

The output of the plant being equivalent to 353,904 ft.-lb. per sec., and the work of the water being 592,420 ft.-lb. per sec., the overall efficiency of the plant operating under the conditions stated is:

$$\frac{353{,}904}{592{,}420} \text{ or } 59.73 \text{ per cent.}$$

Engineers' Study Course

Elementary Mechanics--VIII

Last Lesson's Answers

31. Fig. 29 shows the magnitude and location of all the vertical loads and reactions acting on the crankshaft, when the piston of the engine is on the top dead center.

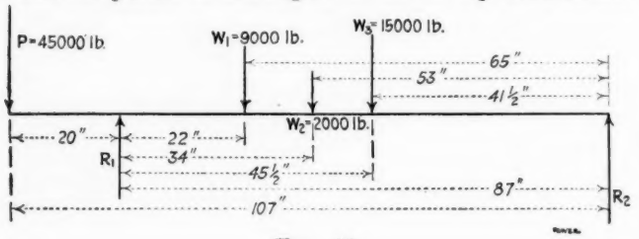


Fig. 29.

In this figure the forces are located both from the reaction R_1 and the reaction R_2. The purpose of this is to facilitate the taking of moments about either point, by clearly showing the moment arm of each force.

Fig. 30 shows the location of all the forces acting on the crankshaft when the piston is on the bottom dead center. In this case the direction of the force P is the reverse of what it was on the downstroke, and hence the reaction R_1 is downward instead of upward as before.

32. Take moments about the point R_1 (see Fig. 29). Thus,

$$-87 \times R_2 + 45\tfrac{1}{2} \times 15{,}000 + 34 \times 2000 + 22 \times 9000 - 20 \times 45{,}000 = 0$$

or $$87 \times R_2 = 948{,}500 - 900{,}000 = 48{,}500$$

and $$R_2 = 558$$

To determine R_1, take moments about the point R_2;

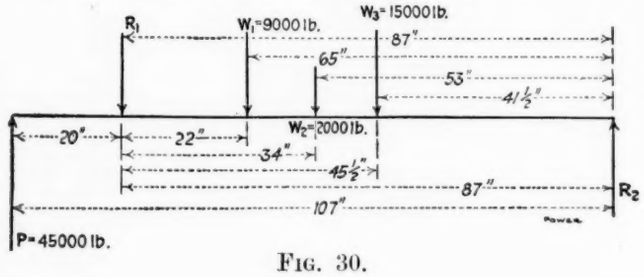


Fig. 30.

thus,

$$-41\tfrac{1}{2} \times 15{,}000 - 53 \times 2000 - 65 \times 9000 + 87 \times R_1 - 107 \times 45{,}000 = 0$$

or $$87 \times R_1 = 6{,}128{,}500$$

and $$R_1 = 70{,}442$$

33. Upstroke. Take moments about the point R_2 (Fig. 30).

Thus,

$$-41\tfrac{1}{2} \times 15{,}000 - 53 \times 2000 - 65 \times 9000 - 87 \times R_1 + 45{,}000 \times 107 = 0$$

or $$87 \times R_1 = 4{,}815{,}000 - 1{,}313{,}500 = 3{,}501{,}500$$

and $$R_1 = 40{,}247$$

To determine R_2, take moments about the point R_1; thus,

$$20 \times 45{,}000 + 22 \times 9000 + 34 \times 2000 + 45\tfrac{1}{2} \times 15{,}000 - 87 \times R_2 = 0$$

or $$87 \times R_2 = 1{,}848{,}500$$

and $$R_2 = 21{,}247$$

34. The accuracy of the results found in problems 32 and 33 can be checked by applying the law $\Sigma V = 0$; thus,

$$\Sigma V = 45{,}000 + 9000 + 2000 + 15{,}000 - 70{,}442 - 558 = 0$$

or $$\Sigma V = 71{,}000 - 71{,}000 = 0$$

This proves that the values of R_1 and R_2 as determined in problem 32 are correct.

For the upstroke, problem 33, $\Sigma V = 0$; thus,

$$\Sigma V = 40{,}247 + 9000 + 2000 + 15{,}000 - 45{,}000 - 21{,}247 = 0$$

or $$\Sigma V = 66{,}247 - 66{,}247 = 0$$

Hence the values of R_1 and R_2 are also correct.

35. The pressure of the steam on the piston, transmitted through the piston rod and the connecting-rod to the crank, does not produce any turning moment since there is no component of the connecting-rod thrust acting in the direction of motion of the pin.

Center of Gravity

A body may be considered as made up of a series of small particles. The weights of all these particles form a system of vertical parallel forces, and the resultant of this system must evidently equal the sum of these forces or the total weight of the body. The point at which this resultant force or weight acts is called the *center of gravity* of the body. As commonly defined *the center of gravity of a body is the point through which the line of action of the weight of the body always passes.*

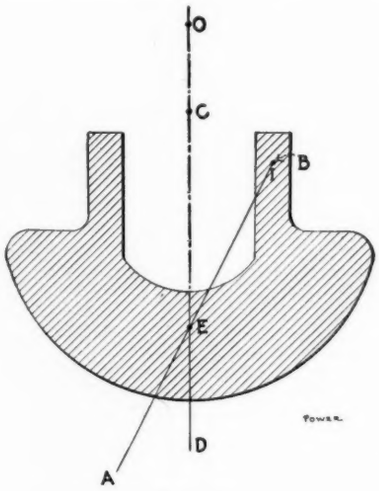


Fig. 31.

In the following discussion the term center of gravity will be abbreviated to the symbol *c.g.* If a bar of uniform cross-section is suspended by a rope attached at one end of the bar it is evident that the bar will hang in a vertical, and not in a horizontal position; or if the rope is attached to the center, the bar will probably assume a horizontal position. Hence a vertical line drawn through the point of suspension of a body must always pass through the *c.g.* of the body.

The *c.g.* of bodies which are symmetrical with respect to a given point, and are of uniform density, will be at the given point. Thus the *c.g.* of a sphere is at its

geometrical center and the *c.g.* of a circle is at its center. The student can readily think of many more examples. Therefore, in many cases the determination of the *c.g.*

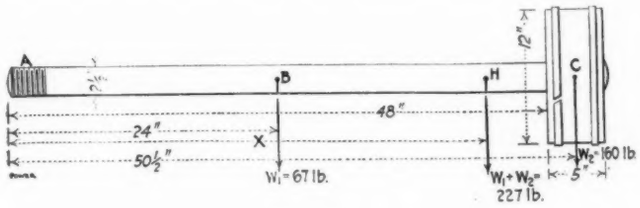


FIG. 32.

is simply a matter of inspection. In the case of unsymmetrical figures the *c.g.* may be found experimentally by making a template of cardboard to represent the body to a given scale. Next suspend the template, first from one point and then from another, and in each case draw a vertical line through the point of suspension. The intersection of these two vertical lines will locate the *c.g.* of the template, from which the *c.g.* of the body can readily be found. Take, for example, the counterweight attached to the crank of certain forms of steam engines. Let the weight be of uniform thickness and its cross-section be of the form shown in Fig. 31, which is a template of the given weight. If the template be supported from the point *O* and the vertical line *CD* be drawn through the point of suspension, then the *c.g.* of the body will lie somewhere on this line. Likewise, if the template be suspended from the point *B* the *c.g.* will lie on the line *AB*. Therefore, the *c.g.* of the body will be found at the point *E* of intersection of the two lines *CD* and *AB*. This method is frequently used in the drafting room, as no computations are necessary.

If a body can be divided into regular geometrical figures, such as triangles, squares and rectangles, the *c.g.* is best obtained by applying the law that the moment of the resultant (which is the total weight of the body) is equal to the sum of the moments of the other forces (the weights of each of the separate figures.)

Problem: At what point would a rope be attached to raise the piston and piston rod in Fig. 32 so that the rod will remain in a horizontal position?

Solution: The rope must be attached at the center of gravity of the piston and rod considered as a single body. This point is found as follows: The weight of the piston rod may be assumed as concentrated at its *c.g.*, which is evidently at the center of the rod, as at *B*. Likewise the weight of the piston is concentrated at its center *C* for the same reason. Let the unknown point be located at *H*, which is x in. from the point *A*, or end of the rod. Take moments about this point *A*.

Thus,

$$24 \times 67 + 50\tfrac{1}{2} \times 160 = 227 \times x$$

or $$227\,x = 9688$$

and $$x = 42.7 \text{ in.}$$

Problem: Fig. 33 shows the cross-section of a riveter frame. Locate the *c.g.* of this section.

Solution: This figure is symmetrical about its vertical axis, and hence its *c.g.* lies somewhere on the line *AB*, say, at the point *H*, x in. from the line *CD*. Divide the section into the three rectangles I, II and III. By inspection it is clear that the *c.g.* of each rectangle is at the point of intersection of the diagonals and also that the weight of each part is proportional to the area of the part. The moment of the weight of each section about any given point will then be proportional to the moment of the area. In dealing with problems of this kind the moments of the areas are usually taken in order to determine the *c.g.*

The *c.g.* of part III is located 9½ in. from the line *CD*, of part II 5¼ in. from *CD*, and of part I ¾ in. from *CD*. The area of part I equals $5\tfrac{1}{2} \times 1\tfrac{1}{2} = 8\tfrac{1}{4}$ sq.in., the area of part II equals $7\tfrac{1}{2} \times \tfrac{1}{2} = 3\tfrac{3}{4}$ sq.in., and the area of part III equals $2 \times 1 = 2$ sq.in.

Now take moments of the areas I, II and III about the line *CD*. The sum of these moments must equal the moment of the resultant (total area).

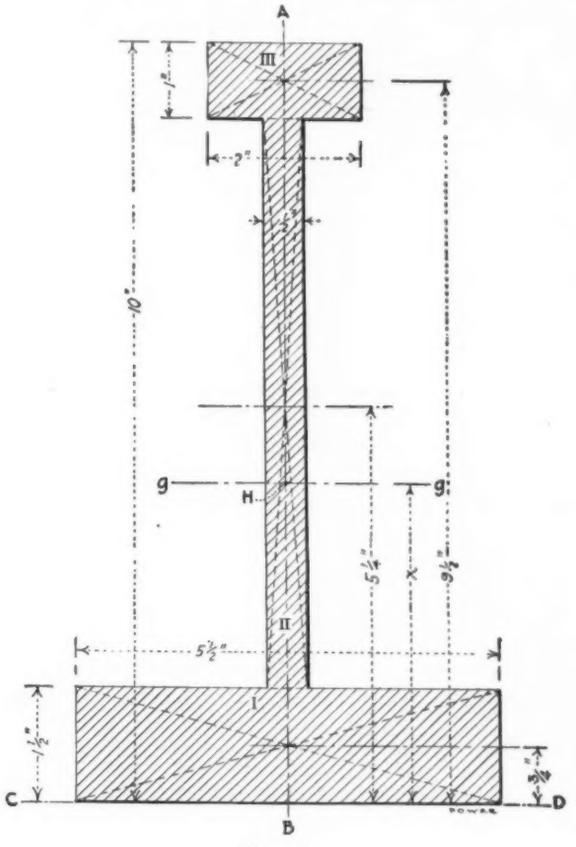


FIG. 33.

Thus,

$$\tfrac{3}{4} \times 8\tfrac{1}{4} + 3\tfrac{3}{4} \times 5\tfrac{1}{4} + 9\tfrac{1}{2} \times 2 = 14 \times x$$

or $$14\,x = 44.87$$

and $$x = 3.2 \text{ in.}$$

STUDY QUESTIONS

36. Locate the center of gravity of a triangle.

37. Does the center of gravity of a body always lie within the body? Illustrate by an example.

38. A hole 4 in. in diameter is punched in a plate which is 15 in. square and of uniform thickness. The center of the hole is located 6 in. from either side. Find the *c.g.* of the punched plate.

39. An iron ball 6 in. in diameter is attached to a rod 2 in. in diameter. If the length of the rod from the end to the point of contact with the ball is 18 in., find the *c.g.* of the ball and rod considered as a single body.

40. The frustum of a right cone is 4 in. high; the diameter of the top is 4 in.; the diameter of the base is 8 in. Find the *c.g.* of the frustum.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Wal, I swan! Whatcha think of a passel of folks as gives an editor an invite to their power show, an' then up an' blacks his eye? 'Swhat they did to our Warren Rogers, over to Boston village lately. Some doin's! Ya-as, b'gum, they fetched little Warren over to the op'ry-house an' hed him alookin' into a tellyscope. Some darn cuss had smeared the eye-hole with lampblack—an' blacked Warren's eye! Pesterin', b'gosh! Warren cal'lates 'twas Jas. Billbryan Myrick as pulled off the josh, an' he'll git Jas. if he has to set up till half-seven every night for a week. Looks like the Myrick place would be shy a farmhand come next Tuesday fortni't.

The centralization of power supply has an eloquent advocate in Samuel Insull, of the Commonwealth Edison Co. His company sold 840 million kilowatt-hours in 1913. In the meantime, chief, we'd better keep on plugging; Sammy won't be able to centralize us all for the next two or three years.

How the men in the moon, the Martians, built their canals is told by an astronomer who thinks he knows. Instead of excavating, as did poor deluded Goethals, they leveled everything in sight and erected walls on the sides of the canal. Wish a Martian would drop down this evening on the Washington folks and tell how the moon men disposed of the toll question.

In a certain monster office building the apparatus was the very latest word in automatic regulation; the management boasted of it, the village populace flocked to see it—and mebbe children cried for it. However, now and once in a while, there was a hitch, and things wouldn't automat worth a dum. One day the assistant chief, who was usually about as funny as a steam table, remarked: "There's only one regular way to get perfect automatic regulation. Some regular feller must invent a regulator to regulate the automatic regulator."

Looking backward 25 years, we find that "Power" said:

That $100,000 will be awarded the inventor who finds a practical way of utilizing the water power of Niagara Falls.

That the new Edison electric lighting station in Philadelphia has hit upon a novel plan. Eighteen 200-hp. engines are to be placed in the basement; over them, 36 dynamos; then the ash floor, and above, the boilers; the fourth floor will contain the coal.

That "One of our contemporaries announces 'The motor of the future. A condensable vapor to take the place of steam.'"

When it comes to war, the man behind the camera is the little red badge of courage. He goes into peril and hardship unflinching and unfaltering—and, perhaps because he is a non-combatant, he is lost sight of in our enthusiasm for the boys behind the guns.

Your Uncle Billy waxed eloquent to The Skipper, our fellow editor, anent the hardships of the war photographers. Skipper said it was no cinch to get pictures in a power plant, either. On a recent skirmish into Pennsylvania, he (200 pounds in the shade) had to scale a five-story building, had a new dollar derby sniped by a hidden pipe, his glasses were shot from off his face, and a hole burned in his panties. All of which seems to prove that Peace hath her damages no less destructive than War.

A mighty good little shop kink is the four-page monthly paper of Stevenson No. 44, of New York City. It is appropriately called "The 44 Booster." Its contents form a local message of optimism, announcements of coming events, joshes, etc. It can't be costly, and it's a live wire in keeping the members interested. The "Booster" could be imitated to advantage by many other locals. We get you, Stevenson, and more power to your journalistic elbow!

As to that "spill" of last week anent the Archibald boy who "invented the pressure," we thank 127 of our alert readers for sending us additional clippings this week. But the brass ring has been given to a Chicago child who is entitled to another ride, free, on the green zebra of our merry-go-round.

Isolated Plant Bests Central Station

By Fred S. Tinkham

About two years ago the management of the Y. M. C. A. in Cambridge, Mass., proposed to make additions to its building that would approximately double its size. Along with this change came propositions for the engineer who had been with them for several years. As usual, the agent of the central station was active. He, of course, maintained that the high efficiency of generating current at their plant enabled them to sell current for much less than it could be produced by a private plant. He also contended that if current was bought outside, a cheaper class of help could be employed for heating, etc., where if a private plant was operated, licensed men would be needed and at a higher wage.

The question was argued at length, and the central-station agent tried to show that his price of 5c. per kw.-hr. was better than could be obtained in the plant. His statements might have been convincing had not records been kept of the old plant for several years previous. These records were looked up and carefully gone over and with the records of the previous year were placed in the hands of a consulting engineer for criticism.

It was found that the current cost them less than 4⅓c. per kw.-hr., allowing the plant a credit for heating the building and paying overhead charges only on that part of the plant not necessary for heating. With the output doubled, the cost of production would be cheaper, so it was decided to install the extra equipment needed.

The present plant consists of two Ames center-crank, high-speed engines, one a 10x12-in. connected to a General Electric machine and the other a 12x13-in. connected to a Crocker-Wheeler generator; three 54-in. horizontal return-tubular boilers, one 12x5x36-in. deep-well pump with a capacity of 40 gal. per min. from a well 400 ft. deep, two National heaters, one large cylindrical-tank heater 10x5 ft. with a trombone coil which heats water for the building and shower baths, one 1½-hp. motor used to circulate the water in the swimming pool, boiler-feed pumps and a pump used when cleaning the bottom of the swimming pool.

The building is five stories high, 120 ft. front, 149 ft. deep and contains 11,866 sq.ft. of radiating surface, which is supplied with exhaust steam from the engines and pumps. When this is not sufficient, live steam is supplied through a reducing valve. During the coldest days but 3 lb. pressure is needed and the average for the season is about 1 lb. A Paul single-pipe system is installed.

The building has a swimming pool 60 ft. long and 20 ft. wide with a varying depth of 4 to 7 ft. It holds 55,000 gal. and is supplied by the deep-well pump. The water is heated by one of the National heaters and a constant temperature of 76 deg. is maintained throughout the day and a part of the night. Each morning an additional amount of water is supplied to compensate for loss over the spit rail and from cleaning the bottom of the tank. This additional water is sufficient to lower the temperature of the water from 76 to 72 deg., making a heat loss of 4 deg. on 55,000 gal. of water to make up daily exeept Sundays. During the year the water in the tank was changed 23 times, so that it was necessary to raise 22 deg. the temperature of 23 × 55,000 gal. of water.

For the year the wattmeters showed that 94,762 kw.-hr. were generated. At the central station's figure of 5c. per kw.-hr. the cost for current alone would be $4738.10. The expenses of the entire plant for the year ending Mar. 31, 1913, were as follows:

Fuel	$4305.00
Labor	2723.00
Oil	77.03
Waste	22.81
Packing	28.77
Water	53.71
Other expenses	579.67
Total	$7789.99

As this is the total operating expense of the plant a division must be made to determine the cost of producing current. From the labor charge of $2723, but $1161.81 is chargeable to power. From the $4305 for fuel a certain proportion should be subtracted for heating the building and heating water for building use and that of the swimming pool.

The heating of the building, located as it is and exposed on all sides, with considerable glass, is calculated on a basis of 22c. per sq.ft. of radiation per season, or a cost of $2610.52.

The total water used in the swimming pool during the year is

$$55{,}000 \times 23 \times 8.33 = 10{,}541{,}666 \textit{ lb.}$$

This must be raised in temperature 22 deg. On a basis of 1 B.t.u. per degree per pound of water, 231,916,652 B.t.u. would be required.

Then making up the 4-deg. drop in temperature on 55,000 gal. daily except Sundays would require

$$4 \times 313 \times 55{,}000 \times 8\tfrac{1}{3} = 573{,}833{,}333 \textit{ B.t.u.}$$

$$573{,}833{,}333 + 231{,}916{,}652 = 805{,}749{,}985 \textit{ B.t.u.}$$

Using a coal with 14,000 B.t.u. per lb. and 60 per cent. boiler efficiency

$$805{,}749{,}985 \div 8450 = 95{,}923 \textit{ lb.} = 47.9 \textit{ tons of coal}$$

At $4.50 per ton the charge against the account for heating the water in the swimming pool would be $215.55.

Then this water has to be pumped from a well 215 ft. deep against an average head of 30 lb. Not less than 10,000,000 lb. of water are raised 285 ft. during the year, an equivalent of 2,850,000,000 ft.-lb. Allowing 15,000,000 ft.-lb. per 100 lb. of coal and a pump efficiency of 50 per cent., 38,000 lb., or 19 tons of coal, would be required. At $4.50 per ton the pumpage would amount to $85.50. Then

$$\$2610.52 + \$215.55 + \$85.50 = \$2911.57$$

Deducting this from the total fuel cost of $4305 leaves $1393.43 as the cost of coal chargeable to power.

The cost of the plant was $7000, but $4500 of this was paid for the old equipment and 80 per cent. has been already charged off for depreciation. This leaves $900 as the depreciated value and adding $2500 for the new equipment gives $3400 as the present value of the plant. Allowing 13 per cent. for fixed charges gives $442. Then the operating charges are as follows:

Labor	$1161.81
Fuel	1393.43
Fixed charges	442.00
Miscellaneous supplies (½ of total)	381.00
Total operating expense	$3378.24

The cost per kilowatt-hour would be

$$\$3378.24 \div 94{,}762 = \$0.0356$$

The central-station charge was

$$\$0.05 \times 94{,}762 = \$4738.10$$

so that under present conditions the station saved per year $\$4738.10 - \$3378.24 = \$1359.86$

No charge is made for several small uses of steam of which it is impossible to even estimate the quantity.

Errata—In the table accompanying the article on Working Up a Boiler Test, on page 593, of the issue of Apr. 28, Item 33 should read, "Item 20 ÷ Item 16, or Item 24 ÷ Item 22 = 8.23."

Item 38 is the efficiency of the boiler and furnace and Item 39 that of the boiler, furnace and grate.

Fourth National Textile Exhibition and Second National Power Show

The Fourth National Textile Exhibition under the auspices of the Textile Exhibitors' Association and the Second National Power Show by the New England Association of Commercial Engineers was held in the Mechanics' Building, Boston, Mass., Apr. 27 to May 2, inclusive.

During the two days' business session of the National Association of Manufacturers the textile industry was thoroughly discussed in relation to foreign trade prospects, which are considered bright, and the effects of labor problems and the tariff, which are thought bad for the cotton mills as a whole.

The business session was held in Paul Revere Hall. President Edwin F. Greene called the convention to order at 11 o'clock Wednesday morning During the session Arthur Tisdale Bradlee, of Chestnut Hill, was presented the 1914 medal in recognition of his contribution to the cause of the industry, a paper of high merit on "Investigations upon the Effect of Moisture in Testing Cotton Yarns and Fabrics"

Governor Walsh was present to extend the Commonwealth's welcome to the cotton manufacturers, and he made a short adress referring to legislation and transportation.

Among the speakers at the afternoon session were ex-Mayor Fitzgerald and Ralph M. Odell, of Washington. Papers were offered at the second, third and fourth sessions.

At the close of the annual meeting Thursday afternoon, Apr. 30, the following officers were elected: President, Albert G. Duncan; vice-presidents, William M. Butler and Grosvenor Ely, and five directors. Nineteen active and six associate members were elected.

Of the papers presented at the convention of interest to engineers was "Electric Power Contracts," by William L. Puffer. "Mill Steam Plants" was not read by the author, A. G. Hosmer, as he was unable to be present.

ELECTRIC-POWER CONTRACTS

In taking up the question of power contracts, Mr. Puffer was of the opinion that, whenever it appeared desirable for a manufacturer to compare the probable cost of producing his own power as against the purchase of it from a service corporation, there is difficulty on the part of the purchaser in understanding the terms used by the seller, because the contract agent begins to talk in what is substantially a foreign language.

It was pointed out that, generally speaking, there is no great difficulty in arriving at some idea of how many horsepower will be required to operate a mill and in estimating the probable amount of time in the year that the assumed horsepower will be used, which result is expressed in horsepower, and may or may not include a proper allowance for overtime, night work, short hours and partial time.

The horsepower year is an expression often used to give definiteness to a statement of the requirement of a mill, but the author gave several definitions which could be applied. A horsepower year might be:

Definition 1. Exactly 1 hp. steadily day and night throughout the year, or 1 hp. × 365 days × 24 hours equals 8760 hours' use of exactly 1 hp.

Definition 2. Exactly 1 hp. steadily day and night through-

out the year except Sundays and, say, three holidays, or 1 hp. × 310 days × 24 hours equals 7440 hours' use of exactly 1 hp.

Definition 3. Exactly 1 hp. steadily for a 10-hour day for every day in the year, or 1 hp. × 365 days × 10 hours equals 3650 hours' use of exactly 1 hp.

Definition 4. Exactly 1 hp. steadily for a 10-hour day except Sundays and, say, three holidays, or 1 hp. × 310 days × 10 hours equals 3100 hours' use of exactly 1 hp.

Defintion 5. Exactly 1 hp. steadily for an eight-hour day excepting Sundays and, say three holidays, or 1 hp. × 310 days × 8 hours equals 2480 hours' use of exactly 1 hp.

The paper points out that if, instead of a heavy load, it fluctuated for a short time by, say 10 per cent., above and below the exact 1 hp., and that if the driving power were limited to exactly 1 hp., the average horsepower could not be operated, and it would be necessary to have an available capacity of 1.1 hp.

If the load never exceeds 1 hp., but because of the stoppage of some machine the full horsepower is not required all of the time, the condition would be more nearly the average man's idea of a horsepower year; this is indefinite because of the unknown amount and time the load falls off.

DEMAND AND LOAD FACTOR

Demand and load factor must be considered in mill-power propositions. Demand is the greatest use of power at any time; the load factor is the percentage which the actual horsepower-hours are to what they would have been if the demand had not been used continuously; or, the load factor is the percentage the average load is of the maximum.

Unfortunately, "load factor" has been used in connection with the day of eight, ten or twenty-four hours, a month or a year of different number of hours, consequently the term is dangerous in a contract unless carefully defined. This is so because no engineer has the means of measuring the actual number of horsepower hours his engine has developed. The best he can do is to take indicator diagrams at times assumed to represent the average load, and then try to estimate or guess the number of hours the load will be or has been used; even then he has no idea of the underload runs and the runs at odd times. The electrical engineer, however, has many simple and accurate methods and instruments which clearly show by charts, dials or pointers, any or all of the desired results.

The electrical terms "kilowatt" and "kilowatt hour" are now generally used in place of horsepower and horsepower hour, the electrical unit being almost exactly one-third larger.

Nearly all power prices are made up of the demand and the load factor charges, in a contract or rate sheet they are indicated by such expressions as "meter," "demand," "service," "readiness to serve," "primary," "first twenty-four hours' use of the demand" and special prices for the first given block of power, etc.

When power is transmitted by alternating currents, it is nearly always found that with the usual types of motors, lines and appliances, that there are times when the current actually flowing through the conducting system is not at all proportional to or commensurate with the transmitted energy. Under the changing conditions of the usual commercial service, this idle or false current varies from a negligible to an extremely serious amount.

The author said that the name given to the cause of this condition is "power factor." The power factor is the percentage ratio between the true energy and the apparent energy, and the true energy is always less than it would seem to be if judged by the current actually flowing. The more nearly 100 per cent. the power factor is, the better; it averages between 80 and 95 per cent. under good conditions, and under bad conditions it may fall to 50 per cent; when at 71 per cent., the current is twice what it would be at 100 per cent. power factor, and the capacity of lines, transformers and the like is taxed as heavily as it would be with two consumers having 100 per cent., yet the purchased kilowatt-hours are but those of one.

Every purchaser of power in any moderately large quantity should protect himself by the use of a continuously operating curve-drawing instrument, making a written record of some factor in connection with the supply of electricity which will be the most service in checking up his power conditions. These instruments are available for the recording of momentary conditions of any electrical quantity and, if properly installed, they produce a record that cannot well be disputed. For example, a curve-drawing demand meter would give a record of the power required, the time of starting, short hours, times of shutdowns and the falling off of the output toward the end of work hours.

There is a tendency to offer the alternative of metering all energy "on high-tension service" at a seemingly attractive low rate. Such rates must be studied carefully to discover the effect of transformer losses, losses in wires and other apparatus which may of necessity be in use for many hours. Usually, small transformers can be substituted in place of the regular service ones during Sunday and the fourteen hours of night use.

All clauses which are worded so as to shift the responsibility for accidents or fires from the supply company to the purchaser should be examined critically and, if possible, struck out; it surely must be a part of the power company's responsibility to so arrange its devices that no dangerous conditions should be brought about on the purchaser's wires or premises, and it is a part of the purchaser's responsibility to see that everything on his side of the company's transformers is proper and safe and that all safety devices required by insurance or other authorities are installed and operative.

ONE-SIDED CONTRACT

Common sense and justice should be evident in power contracts, and no attempt made to handicap either party to the contract. At times, it happens that queer provisions are brought about by a combination of clauses which are in themselves not intended to injure.

The author mentioned a contract which he condemned because, if taken literally, the mill could never grow, as the company was to buy power up to a definite and final limit and was forbidden to build a plant of its own, make its own light or get it elsewhere, and all the electric lighting was expressly cut out of the contract. The power company did not have to give notice of refusal to continue the contract until the day before it expired. There were no offsets for poor service, loss of power, low voltage or low frequency. These things were not evident to the ordinary reader and probably were not purposely designed, and yet they were very definitely and carefully stated, partly in the body of the contract and partly in the fine print "conditions." As finally signed, all these matters were settled and arranged on an equitable basis.

Power Show

In connection with the textile exhibition was the "Power Show," the exhibits being displayed in the lower floor of the building. This department received its full share of interested visitors. Thursday, being Engineers Day, many engineers visited the exhibits, which were attractive, and in several instances showed new devices of interest to power-plant men. The booths were tastefully arranged and the attendance of visitors kept up well until the close of the show. The following firms exhibited at the power show:

LIST OF EXHIBITORS

Albany Lubricating Co.
American Oil Company
American Power Company
Ames, Bradford L.
Am. Steam Gauge & Valve Mfg. Co.
Anderson Company, V. D.
Anderson, George P.
Ashton Valve Company
Atwood & Morrill
Autoforce Ventilating System
Autogenous Welding & Equipment Co.
Austin & Doten

Badger & Sons Co., E. B.
Betson Plastic Fire Brick Co.
Blanchard, J. Henry
Buckeye Engine Company
Burgmann Asbestos & Packing Mills
Byers Company, A. M.

Cave Welding Company
Chapman Valve Mfg. Co.
Chesterton Co., A. W.
Climax Smoke Preventer Co.
Coppus Engineering & Equipment Co.

Dearborn Chemical Company
Diamond Power Specialty Co.
Dixon Crucible Co., Joseph
Durabla Manufacturing Co.

Eagle Oil & Supply Co.
Economy Lubricating Co.
Edward Manufacturing Co.
Electric Smelting & Aluminum Co.
Evans Mill Supply Co.

Falk Co., The
Foster & Sons Co., F. W.

Gardner Grate Company
Garlock Packing Company
Griscom Russell Co., The

Haines & Co., Wm. S.
Harrington Mfg. Co.
Harrison Safety Boiler Works
Harvey Company, Arthur C.
Hyland Mfg. Company, W. J.

International Engineering Works, Ltd.

Jefferson Union Company
Jenkins Bros.

Kelly & Company, Inc , T. P.
Keystone Lubricating Co.

Lagonda Mfg. Company
Lead Lined Iron Pipe Co.
Lieberknecht & Co., F. W.
Litchfield, J. M.
Locke Regulator Co.
Lunkenheimer Company.

Mason Regulator Company
Massachusetts Fan Company
McClave-Brooks Company
McLeod & Henry Company
Miller's Sons, Wm. P.
Monarch Steam Blower Co.

Nashua Machine Company,
"National Engineer"
National Tube Company
N. E. Association of Commercial Eng.
Nightingale & Childs Co.
Norristown Magnesia & Asbestos Co.

Open Coil Heater & Purifier Co.

Patterson Lubricating Co.
Perfection Grate Company
Philadelphia Grease Mfg. Co.
"Power"
Pratt & Cady Company, Inc.

Reynolds Oil and Supply Co.
Robinson & Son Co., Wm. C.
Rose, P. R.
Roto Company, The

Schaeffer & Budenburg Mfg. Co.
Schumaker-Santry Co.
Shaw Propeller Co.
Simplex Tester Co.
S. K. F. Ball Bearing Co.
"Southern Engineer"
Stone, Herbert E.
Strong, Carlisle & Hammond Co.

Texas Company, The
Thermograde Valve Co.

Under-Feed Stoker Co. of Am., The
United States Graphite Co., The

Vasil Fuel & Steam Systems Co.

Walworth Mfg. Company
Watts Regulator Company
Webster & Company, Warren

Coming National and State Conventions

The following is a list of the coming national and state conventions as fully as can be ascertained up to the present time:

NATIONAL CONVENTIONS

National Association of Stationary Engineers, Milwaukee, Wis.	Sept. 7-12
American Order of Steam Engineers, Baltimore, Md.	June 1-6
Universal Craftsmen, Council of Engineers, Cleveland, Ohio.	Aug. 4-8
Canadian Association of Stationary Engineers, Ottawa, Ont.	July 28-30

STATE ASSOCIATION CONVENTIONS OF THE N. A. S. E.

Illinois, Peoria	May 20-22
New Jersey, Jersey City	May 28-30
Iowa, Des Moines	June 3-5
Kansas, Atchison	June 3-5
Kentucky, Louisville	June 3-5
Indiana, Indianapolis	June 10-12
New York, Rochester	June 11-12
Ohio, Akron	June 17-19
Pennsylvania, Philadelphia	June 19-20
Connecticut, Bridgeport	June 26, 27
New England States, Providence	July 9-11
Michigan, Muskegon	July 15-17
Missouri, St. Joseph	July 29-31
Minnesota, Minneapolis	Aug. 12-14
Wisconsin, Milwaukee	Sept. 4
Texas, Fort Worth	———
West Virginia, Clarksburg	———
California	———
Colorado	———

New Haven Engineers Meet

Aëronautics was the topic for discussion at the quarterly meeting of the New Haven Section, A. S. M. E., held at the Mason Laboratory, Yale University, on May 1. E. S. Cooley, chairman of the section, presided, and the afternoon session was given up to three papers: "A Review of Aëronautical Progress" (illustrated), by J. J. Long, of Brown University; "Fuels for Internal Combustion Engines," by D. B. Pangburn, of Sheffield Scientific School; and "Aëroplane Motors," by Prof. D. L. Gallup, of Worcester Polytechnic Institute. Also, J. A. Steinmetz discussed aëroplanes from the military standpoint.

At the evening session, Prof. Breckenridge presided, President Hartness, of the society, gave an informal address, and two regular papers were presented: "The Evolution and Status of Aëronautics," by Henry Woodhouse, editor of "Flying," and "Representative American Aëronautical Motors," by Howard Huntington.

National Gas Engine Association to Meet in June

The tentative program of the seventh annual meeting of the National Gas Engine Association, to be held in Chicago on June 24, 25 and 26, has been given out. This includes, besides the president's address, by R. A. Oglesby, and the reports of the various committees, the followrng papers: "Horsepower Rating and Standard Brake," by Prof. P. S. Rose; "Catalogs," by Prof. G. W. Munro; "Coöperating with and Assisting the Dealer," by G. M. Matsan, and "Heavy Oil Engines in Small Units," the author to be announced later. In addition there will be the usual entertainment features.

The committee invites suggestions from members for the improvement of the program.

How Villa Paid for a Motor

The agent for the Westinghouse Electric & Manufacturing Co., at El Paso, Texas, sent a draft to the Pittsburgh office recently with a letter explaining the sale. General Villa, the Mexican Constitutionalist leader, bought a motor to be used in pumping water for a camp. Villa offered rebel scrip in payment and was informed that this was valueless in America. Villa then dispatched a squad to a nearby town, raided a gambling house, and returned with several bags of American gold. With this he paid for the motor.

Philadelphia's "Get-Together" Engineering Mass Meeting

The scientific and engineering men of Philadelphia are preparing for a big mass meeting on the evening of May 15 in the Continental Hotel roof garden. During an informal smoker, prominent engineers will give short addresses, and there will also be music and a general entertainment.

Some twenty national and local societies having fully 4500 members in and near the city will be represented. This is to be the first of a regular series of general meetings. No long program will be attempted, but rather a "get-together" meeting to inaugurate an engineering congress each year.

Among the speakers will be Dr. C. P. Steinmetz, the General Electric Co.; Walton Clark, the United Gas Improvement Co., and president of Franklin Institute; Dr. Humphreys, president of Stevens Institute of Technology, and James Mapes Dodge will act as toastmaster.

Members of the national engineering and scientific societies of other cities are cordially invited. The tickets are $2 each and are to be obtained from C. C. Tutwiler, 1630 Real Estate Trust Building; Dr. R. B. Owens, of Franklin Institute, or from the Engineers Club of Philadelphia.

Lomax, Ill., Power Plant

Lomax, Ill., recently signed a contract for the first unit of a power system. This system is to furnish light, heat and power for the entire new preplanned city of Lomax. Their buildings and plant are so constructed that the new units may be added without interfering in the least with the daily business of those already installed. While they will furnish steam heat to the factory district and to the Free Vocational University that is to be built, in any different district the power furnished will be largely electric. This first unit consists of two fire-tube boilers, 450 hp., and a Hamilton-Corliss engine, a generator, pumps, heaters, tanks, fire pumps for protection for the factory district, etc.

The contract was let to the Gale Installation Co., Chicago. The buildings will be erected by local contractors, the work for the foundations being well under way. The plant is being erected from private plans.

Railroads Must Stop Smoke Nuisance

Notice has been served on the railroads entering Pittsburgh by city council calling upon them to observe the smoke-prevention ordinance. The chief smoke inspector, J. W. Henderson, was instructed by the councilmanic committee on health to notify the railroads that within three months they must comply with the smoke ordinance, otherwise the ordinance to compel them to use smokeless fuel on locomotives would be passed. This ordinance temporarily was laid over.

The Pennsylvania R.R. had sent a communication to the health committee giving reasons why, in the opinion of its engineers, it would be impossible, unless at great expense, to comply with the proposed ordinance requiring the use of smokeless fuel. There also was a letter from Smoke Inspector Henderson showing that in other cities smokeless fuel is in use on locomotives, and that in Pittsburgh the Pittsburgh & Junction operates its shifting engines with smokeless fuel.

Massachusetts Heating and Ventilating Engineers Inspect New Theater

After the transaction of the business of the regular meeting in April and enjoying a banquet, the Massachusetts Chapter of the American Society of Heating and Ventilating Engineers adjourned to make an inspection of the heating and ventilating plant of the new Scollay Square Olympia theater which is the largest popular-priced vaudeville and moving picture theater in New England, seating 3200 people. This ventilating system is the most modern and complete system of any yet inspected in this vicinity. The owners have gone to much expense to make it a recognized public benefit.

The system was designed and supervised by the Richard D. Kimball Co. and consists of a fresh air supply for the theater proper and all public rooms, and a separate exhaust system for the main house, gallery, balcony, public rooms and dressing rooms. Outdoor air first passes through the primary Vento heaters in the heater room, which is under the main auditorium floor, through the Carrier air washers, then through the secondary heaters to a fresh air American blower discharging part of the air into the plenum space between the auditorium floor and the basement ceiling, also to the public rooms, the remainder being discharged into the plenum space

under the balcony. The air then passes into the theater and is distributed through mushrooms located under the seats of the auditorium and the balcony floors, so that practically every person in the audience has an individual fresh air supply.

The air washer and fan systems are especially to be noted because they are equipped with all the necessary apparatus for keeping the air supplied to the theater at the proper temperature and humidity. The air is exhausted from the theater by means of three 48-inch propeller fans; one under the balcony, another under the gallery and the third in a penthouse on the roof; large grilles in the soffits of the balcony, gallery and main ceiling are connected to the fans by means of ample galvanized iron ducts.

Every effort was made to have the air of the public rooms and dressing rooms just as fresh as that of any other part of the theater. The air in all public rooms is changed at least 12 times per hour by a propeller fan. Large vent grilles are in the ceiling of the dressing rooms and connected to a powerful propeller fan under the stage and discharged outdoors.

The heating system is of the vacuum type. Two horizontal tubular 66-inch boilers with 16-foot tubes, equipped with smoke consumers and Smith settings, supply the steam required for this theater, and also for the large office building connected therewith and another adjoining theater. All direct radiators are concealed behind neat grilles and under Johnson service thermostatic control.

NEW PUBLICATIONS

THE FUELS USED IN TEXAS By William B. Phillips and S. H. Worrell. Published by the University of Texas. No. 35 of the Scientific Service of the University's Bulletin.

Messrs. Phillips and Worrell frankly state that while Texas has enormous supplies of good and cheap fuels, it is not being utilized to the best advantage. Of the original supply of eight billion tons of coal, the production since 1895 has been thirteen million tons, merely scratching the surface, so to speak. Texas has a workable lignite area of 50,000 square miles, and yet in the last 19 years but eight million tons have been produced from an original supply of about 30 billion tons.

As compared with some other coals, say the authors, the Texas coals, while not of the best quality, have been used with excellent results, the greater part by the railroads. The lignite industry has rapidly increased, and the authors believe that on the establishment of large power plants, lignite will be used to good advantage.

Of the 16 chapters composing this pamphlet of 287 pages, chapters 2 to 5 treat of the location and the production of the Texas fields, coal composition, its analysis, the dry distillation, production and value of coal gas and of oil and water gas: Chapters 6 to 12 are devoted to lignite, its composition and preparation, its use under stationary boilers, the heating value of briquettes, and the recovery of byproducts in distillation. Chapter 14 gives the comparative efficiency of coal, lignite and petroleum products in Texas.

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Illinois' Coal Production—Illinois is producing 62,000,000 tons of coal per year, more than one-eighth of all the bituminous coal mined in the United States. The safety of the miners and the efficiency of the mining methods employed are therefore matters of national concern. The department of mining engineering of the University of Illinois, the State Geological Survey, and the United States Bureau of Mines have coöperated during the past three years to study Illinois mining conditions. The information collected at 100 mines is published in district reports. In Bulletin No. 2, "Coal Mining Practice in District VIII (Danville)," by S. O. Andros, are discussed causes of accidents to miners in Vermilion and Edgar counties, loss of natural resources by wasteful methods of blasting and mining, use of steel and concrete as substitutes for timber in the mines and other phases of underground mining. The bulletin also contains a description of the methods of removing the overburden from a coal bed by steam shovel, a system of mining which has been highly developed in this district. Copies of the bulletin may be obtained by addressing State Coal Mining Investigations, Urbana, Ill.

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In Valves and Pumps where water under high pressure attains a high velocity it has been a general experience that gray iron and steel are subjected to peculiar cutting action more marked when two dissimilar metals are in contact.

ENGINEERING AFFAIRS

At the Boston Engineers' Club, on May 13, Capt. Charles H. Manning and other well known engineers will be the speakers. The topic will be "Boiler-Room Practice."

Instead of the usual annual excursion, an outing and field day will be held on Sunday, May 31, by the Combined Associations of Engineers in the Borough of Brooklyn. The Combined Associations include Local Associations Nos. 8, 27, 41, 57, Melville Council No. 9 and the Modern Science Club.

An illustrated lecture on "Boiler-Room Practice," covering all the essential details of modern methods, will be given at the Modern Science Club, 125 South Elliott Place, Brooklyn, N. Y., on Tuesday evening, May 19, at 8:30. The speaker will be Charles H. Bromley. The club invites and welcomes all engineers and others interested in power-plant economy and operation to avail themselves of the opportunity to hear this interesting and instructive lecture.

On the evening of April 20 a delegation from the Brotherhood of Power Workers, Springfield, Mass., visited Middletown, Conn., and organized a local of the Brotherhood. It begins with 25 members, and has already planned an educational campaign in the shape of illustrated lectures. The new officers are, President, W. M. Stockwell; vice-president, H. S. Willows; treasurer, E. S. Lewis; financial secretary, W. Rasche; corresponding secretary, R. A. McKeon; recording secretary, F. E. Davis; conductor, H. E. Ackerley; doorkeeper, E. J. Johnson; trustees, R. A. McKeon, C. A. Chatman, W. Rasche; grievance committee, E. S. Lewis, T. E. McAlpine, L. O. Taylor.

The Detroit Engineering Society held its twentieth annual meeting and election of officers Apr. 17. Many of the past presidents of the society addressed the meeting. The following officers were elected for the ensuing year: President, H. H. Esselstyn; first vice-president, O. W. Albee; second vice-president, W. S. Blauvelt; secretary and treasurer, F. H. Mason. The society has a membership of 504, action on 47 applications for membership pending. A meeting was held May 1. L. A. Hawkins, research engineer of the General Electric Co., presented a paper on "Industrial Research."

The Mechanical Engineering Society of the Massachusetts Institute of Technology, Boston, Mass., held its dinner on the evening of Apr. 29 at the American House. The members had the opportunity of hearing several speakers of national reputation in mechanical circles, including Prof. William Kent, Charles T. Main, Prof. E. F. Miller, Prof. G. B. Haven and Prof. G. E. Russel.

OBITUARY

HARRY R. GILBERT

Harry Rush Gilbert, aged 68, manager of the Continental Works of the National Tube Works Co, Pittsburgh, Penn., died on Apr. 26 at his home in Beechwood Boulevard, that city.

PERSONALS

R. C. Cole has joined the staff of the pneumatic tool department of the Ingersoll-Rand Co., and has been stationed at the Chicago office.

A. P. Singer, formerly engineer at the Spy Run power station of the Fort Wayne & Northern Indiana Traction Co., has resigned to accept a position with the Tennessee Power Co.

E. S. Cooley, for several years mechanical engineer with the New York, New Haven & Hartford R.R., will leave to take up the position of commercial engineer with the B. F. Sturtevant Co., at its New York office.

E. F. Walker, formerly sales manager of the hydraulic department of the International Steam Pump Co., will represent the Eynon-Evans Manufacturing Co. in New York and vicinity, with an office at 170 Broadway.